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Published Monthly by
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS
at Easton, Pa., and edited by
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APPLIED MECHANICS Reviews

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Subscription and Production Office: **The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U.S.A.**

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APPLIED MECHANICS REVIEWS, May 1954, Vol. 7, No. 5. Published monthly by The American Society of Mechanical Engineers at 20th and Northampton Streets, Easton, Pa., U. S. A. The editorial office is located at the Midwest Research Institute, Kansas City 2, Mo., U. S. A. Headquarters of ASME, 29 West 39th St., New York 18, N. Y., U. S. A. Cable address: "Dynamic," New York. Price $1.50 per copy, $12.50 a year; to members of ASME and co-operating societies $0.75 per copy, $9 a year. Extra postage to countries not in the Pan-American Union, $1.50; to Canada, $0.75. Changes of address must be received at Society headquarters seven weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Laws: The Society shall not be responsible for statements or opinions advanced in papers or printed in its publication (B13, Par. 4). . . . Entered as second-class matter, January 11, 1948, at the Post Office at Easton, Pa., under the Act of March 3, 1897. Copyrighted, 1954, by The American Society of Mechanical Engineers.

APPLIED MECHANICS REVIEWS

VOL. 7, NO. 5 MARTIN GOLAND *Editor* MAY 1954

REVIEW OF RESEARCH AND DEVELOPMENT IN AUTOMOTIVE ENGINES

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THE development of automotive power plants shows three distinctive phases.

Phase 1: Pioneering in a new field of power plants, inventor and builder were happy to produce engines which would run at all. Drawing heavily on the experience and practices of the steam engine, the multicyclinder spark ignition engine of the early 1920's was developed.

Phase 2: Reliability and producibility characterize this period. During this time the American automobile developed from a luxury item to a commodity. The truck became a major factor in economy and transportation. The striving for low cost per mile brought on the development of the lightweight high-speed diesel engine. Roads and service facilities developed along with the increased number of vehicles used. With better roads the range of vehicles extended beyond the confines of the cities and cars became a common mode of long-distance travel. Along with this arose the need for higher performance, i.e., high top speed, rapid acceleration, and good hill-climbing ability, each one increasing the necessary power. Simultaneously the spark ignition aircraft engine was developed rapidly to high specific powers and low specific fuel consumption. This gave much impetus to an intensive study of the problem of knock or detonation and the development of high octane fuels.

Phase 3: Phase 3 may be said to have begun at the end of World War II. It is characterized by refinement in all details with the aim to increase performance without increasing materially the size and speed of reciprocating engines.

The present review is primarily concerned with Phase 3.

Research and development are carried on in the following areas: (1) Engine transmission relationship; (2) combustion control; (3) improvement in air flow through the engine (breathing); and (4) gas turbines for vehicles.

1 ENGINE-TRANSMISSION RELATIONSHIP

Caris and Richardson (1)[1] pointed out that engine and transmission should be considered together and in their relation to the required vehicle performance. An ideal transmission is defined as one which, at all times, permits the engine to operate on the envelope of the consumption loops (plot of brake specific fuel consumption, lb/bph-hr, vs. brake mean effective pressure, psi, with engine speed as parameter). If this is translated into a plot of economy (miles per gal) vs. vehicle speed (mph), it becomes apparent that a potential improvement of 100% can be realized. This gain is impressive if compared with the relatively modest improvements which can be hoped for from lowered specific fuel consumptions alone. The ideal transmission is not within easy reach. Present automatic transmissions are designed for ease of handling, control, and driving comfort (2, 3, 4). Truck transmissions with their large number of gear ratios come closest to the ideal transmission (5).

The essentials of the concept of the ideal transmission have previously been expressed in the foreign automotive literature (6).

2 COMBUSTION CONTROL

The *effects of compression ratio* on engine performance were recognized early. In their classical paper, Goodenough and Baker (7) analyzed these effects. A logical extension of these thoughts was made by Kettering and others (8, 9, 10), and a family of engines based on these concepts have been put into production (11–15).

A striking example of the effect of compression ratio on over-all performance is given by McCuen (16).

Comparison of different engines does not necessarily give a clear picture of the effect of compression ratio. For this reason, Roensch (17) has varied the compression ratio on one production multicylinder engine and analyzed the effects on power, fuel consumption, and heat rejection.

Engine-Fuel Relationship. With increasing compression ratios the octane requirement of engines increases. Kettering has stated that the petroleum industry is perfectly capable of producing fuels of any required octane rating, if the need arises. Fuel technologists and refiners have essentially lived up to this expectation. They, nevertheless, view increases in compression ratio without enthusiasm. The petroleum industry's problems are reviewed by Mount (18). Modern refining techniques yield fuels of high octane numbers. Further increases are obtained by addition of tetra-ethyl-lead. For a considerable period of time attention was focused on the knock behavior of fuels and engines and their mutual adaptation (19–25).

[1] Numbers in parentheses indicate References at end of paper.

It appears that knock is of the greatest importance to engine operation. Much effort has been spent on studies of the mechanism of knock ever since this has been recognized. Withrow and Rassweiler (26) took photographs of the flame-front development in a running engine through a quartz window, showing that knock is a sudden reaction of the end gas (the unburned portion of the mixture which has not yet been reached by the flame front). This end-gas reaction is accompanied by a rapid pressure rise and the familiar ping. The exact mechanism of the reaction is not known, but relations between molecular structure and knock (27) have been established. A very detailed summary of references has been prepared by Boyd (28). Considerable work in this field was done by the NACA, which has recently been summarized (29).

Detection of knock and measurement of its intensity are based on observation of the rate of pressure rise in the cylinder (dp/dt) and numerous instruments have been developed for observation and quantitative measurement (30, 31, 32).

Precombustion Reactions. Although knock occurs late in the cycle, it is merely the dramatic climax of a chain of events which begins as soon as the intake valve closes and the mixture is compressed. As much as 10 per cent of the heat of reaction may be released before a flame front is established by the firing of a spark (33–37).

Preignition. Distinctly different from knock (end-gas reaction) and precombustion reactions is the phenomenon of preignition, also called wild ping or uncontrolled combustion, which denotes all forms of ignition of the charge which is not a direct result of the spark. As the name implies, preignition occurs early in the cycle, before the spark is fired. It is induced by hot spots in the cylinder.

Although preignition has been known to occur in aircraft engines (29, 38), it has only recently become a major problem in vehicle engines (40). There are passenger-car engines that are preignition-limited in performance rather than knock-limited (41). Identification of preignition as contrasted with knock and the measurement of the frequency of occurrence requires special instrumentation (42).

Engine Deposits. It has been established that deposits on the walls of the combustion chamber are the primary cause of preignition. Deposits may induce knock as well as preignition and have been studied from this point of view (43–46). Flame photographs have been taken (47) in order to study the effect of deposits. This study also showed that deposits may be purged or scavenged from the combustion chamber, a fact which is well known to operators of engines.

Removal or suppression of the harmful effects of deposits by additives to the fuel has been studied (48). Phosphates seem to be particularly effective in this respect, and tri-cresyl-phosphate (TCP) is used commercially for the purpose in motor fuel.

Engine Roughness. Knock as well as preignition is accompanied by a rapid rate of pressure rise in the combustion chamber. The engine structure deforms under such rapidly applied forces. The crankshaft is excited to combined bending and torsional vibrations which are observed as engine roughness. Even without the occurrence of preignition or knock, rapid rates of pressure rise may cause roughness. Combustion-chamber design as well as structural stiffness of the engine are the two major factors affecting roughness. Engine roughness was recognized and defined early (49, 50). The interaction between engine structure and pressure development was investigated by Withrow and coworkers (51, 52). The behavior of the flywheel appears to be of special importance (53).

Fuel Injection. The existence of precombustion reactions and the length of the ignition delay or induction period suggests late injection of gasoline (about 40°–60° before top dead center) directly into the cylinder. There is no time for prereaction; as a matter of fact, formation of an end-gas zone can be avoided altogether. This was investigated by Mikita (54) and others (55) and is known as the Texaco combustion process. The test engine operates successfully on 50 octane fuel with a compression ratio of 10 to 1. No multicylinder development along this line has been reported on in this country. The fuel-injection systems mentioned in connection with racing cars are low-pressure manifold injection systems and represent merely a substitute for a carburetor.

The full capabilities of direct injection have not been utilized in automotive engines, although they have been discussed (56, 57). An experimental multicylinder engine with injection has been tested in England (58). Considerable interest in direct injection exists in Germany (59), and two small two-cylinder two-stroke engines (Gutbrod and Goliath) are in production, using fuel injection (60). Specific fuel consumptions near 0.5 lb/bhp-hr have been reported over a fair operating range, and smooth running has been obtained from idle to full load.

The increasingly complicated and costly carburetors necessary with modern engines tend to eliminate high initial cost as an objection to injection systems.

Anti-Detonant Injection. Injection of water or alcohol or a mixture of both has been successfully employed to suppress detonation in reciprocating aircraft engines. This technique has been applied to automotive engines (61–64), but has not found widespread acceptance.

3 IMPROVEMENT IN AIR FLOW THROUGH THE ENGINE (BREATHING)

Any increase in air flow through spark or compression-ignition engine is a potential gain in specific power output (bhp/cu in.). C. F. Taylor and co-workers have contributed fundamental investigations concerning the volumetric efficiency of both four-stroke and two-stroke engines (65, 66). Two German investigators who have been working on the breathing problem for the past 25 years have recently published their latest findings (67, 68). The problem of the exhaust and intake process as well as of manifolds for multicylinder engines has occupied both research men (69–72) and development engineers (11–15).

Supercharging has received considerable attention (73–77) both as applied to spark and compression-ignition engines.

Utilization of exhaust energy to drive the supercharger is, of course, thermodynamically most attractive. It presents, however, problems on vehicle engines which have to accelerate and decelerate very frequently, an operation which a high-speed (15–20,000 rpm) turbocharger cannot readily follow (78–82).

4 GAS TURBINES FOR VEHICLES

The success of small gas turbines (100–300 hp) for auxiliary power has encouraged investigation of the suitability of gas turbines for vehicle propulsion (82–86). An aircraft auxiliary turbine was adapted as a truck power plant by Boeing (87, 88, 89) and has demonstrated the feasibility of the scheme. Rover in England (90) and General Motors (91) in the United States have built experimental gas-turbine cars. Characteristics of small turbines are discussed by Wood (92) and Alpert (93).

It appears (82, 85) at present that the most promising application of the gas turbine is in heavy-duty vehicles, most likely in the role of an overload power plant in conjunction with a smaller reciprocating power plant for cruising.

Unconventional Cycles and Configurations. Steam power plants for vehicles have been studied from the thermodynamic point of view (94), and several such power plants are at present under development.

Combinations of reciprocating engines and gas turbines have been investigated and developed (95, 96) for large power plants. One modification, the free piston gas generator (97, 98) shows promise for vehicle applications.

The compounded reciprocating engine (two stages of expansion, high and low-pressure cylinder) was abandoned completely in this country. It still commands some interest in Germany (99).

Similarity Laws for Reciprocating Engines. The problem of similarity has received attention repeatedly (100). Recently C. F. Taylor has contributed considerably to our knowledge in this area (101, 102).

Engine Lubrication. A great deal of research and study has been made in the field of engine lubricant relation, lubricant development, and lubricant performance. A complete review and bibliography have been prepared by Georgi (103). A few additional references on specific subjects may be useful.

Radioactive tracer techniques have greatly facilitated research in engine wear (104, 105, 106).

The problem of engine wear and its control by the lubricating oil is of the greatest importance and has been studied extensively (107–110).

Characteristics and nature of the additives used to control the behavior of engine lubricating oils are not generally presented in detail in the engineering literature. Nevertheless, much insight into their action can be gained from a study of chemical aspects as put forth by chemists (111, 112).

Synthetic lubricants have been developed and tested and are finding some application (113).

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Books Received for Review

Bickel, E., Die metallischen Werkstoffe des Maschinenbaues, Berlin, Springer-Verlag, 1953, x + 442 pp., 456 figs. DM 37.50.

Booth, A. D., and Booth, K. H. V., Automatic digital calculators, New York, Academic Press, Inc.; London, Butterworths Scientific Publications, 1953, vii + 230 pp. $6.

Bullen, K. E., An introduction to the theory of seismology, New York, Cambridge Univ. Press, 1953, xvi + 296 pp. $6.50.

KELLOGG, F. H., Construction methods and machinery, New York, Prentice-Hall, 1954, xv + 415 pp. $10.

KOZENY, J., Hydraulik, Wien, Springer-Verlag, 1953, xi + 588 pp., 544 figs. $21.

OPPELT, W., Kleines Handbuch technischer Regelvorgänge, Weinheil/Bergstr., Verlag Chemie, 1954, 448 pp., 353 figs., 110 tables. DM 31.80.

SWAINGER, K., Analysis of deformation, Vol. I. Mathematical theory, London, Chapman & Hall, Ltd., 1954, xix + 285 pp. 63s.

TIMOSHENKO, S. P., Collected papers, New York, McGraw-Hill Book Co., Inc., 1954, xxv + 642 pp. $15.

YOUNG, J. F., Materials and processes, 2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, ix + 1074 pp. $8.50.

Letters to the Editor

1352. Concerning AMR 7, Rev. 65 (January 1954): A. Mehmel and W. Fuchssteiner, On an approximation method for the analysis of circular cylindrical shells.

Professor M. Salvadori kindly called my attention to the publication, "Design of cylindrical concrete shell roofs," Manual of Engineering Practice No. 31, of the ASCE, 1952. This publication, 177 pages long, deals extensively with the theory and the practical applications of barrel structures. It also provides tables to facilitate the calculations. G. Horvay, USA

1353. Concerning AMR 7, Rev. 437 (February 1954): R. Hiltscher, Photoelastic investigation of elastoplastic states of stress.

We regret that the following typographical errors appeared in the above review:

p. 60, column 2, line 8: The word "statically" should be deleted and replaced by the word "statistically."

p. 60, column 2, line 17: The word "represent" should be deleted and replaced by the word "present."

1354. Concerning AMR 7, Rev. 559 (February 1954): E. A. Eichelbrenner, An approximate method of calculation of the laminar compressible boundary layer for external pressure gradient, temperature law at the wall, and for any Prandtl number.

In processing the manuscript for this review, certain ideas were changed through improper editing. The sixth sentence in the second paragraph should read as follows:

The energy equation, which is nonlinear in T but linear in τ^2 and in its derivative, is then used for computing $\tau^2(x,y)$.

Theoretical and Experimental Methods

(See also Revs. 1390, 1402, 1414, 1420, 1513, 1547, 1585, 1597, 1620, 1666)

1355. Barnes, C., Partial differential equations in engineering problems, New York, Prentice-Hall, Inc., 1953, viii + 254 pp. $4.75.

An attractively presented textbook dealing with the fundamentals of partial differential equations, their derivation and solution. Written for the student of engineering rather than mathematics, emphasis is on method rather than mathematical rigor. Book includes, among other things, a comprehensive treatment of Fourier series and the Fourier integral, but does not elaborate on methods of transformation calculus other than those involving the Fourier transform. E. J. Martin, Jr., USA

1356. Southwell, R. V., Some extensions of "Rayleigh's principle," *Quart. J. Mech. appl. Math.* **6,** part 3, 257–272, Sept. 1953.

Rayleigh's principle [*Proc. Lond. math. Soc.* **4**, 357–368, 1873; *Si. Papers* **1**, 21; "Theory of sound," **1**, secs. 88–89, 1945, Dover Publ.] states that if an eigenvalue λ of a characteristic value problem is expressed as a ratio of two appropriately defined quadratic forms (usually representing energies), then: (1) λ is stationary with respect to first-order variations of w, the approximate solution (on which λ is based), about the exact solution to the associated equations of (static or dynamic) equilibrium; and (2) the approximate value of λ lies between the least and greatest of the exact eigenvalues and, therefore, represents an upper bound to the former. Postulates antecedent to (1) and (2) are: (A) The solution may be expanded in normal nodes (implying a finite number of freedoms); and (B) the problem is such that the eigenvalues (squares of natural frequencies in dynamical problems) are all positive. Author retains (A) but generalizes (B) to allow either positive or negative (but still real) eigenvalues and then proves that (1) is still valid and, in place of (2): (3) the approximation λ cannot lie between the least positive (λ_1) and least negative (λ_{-1}) eigenvalues (theorem due to Miss G. Vaisey); (4) the approximation to the square of the eigenvalue obtained with the aid of the first "intensification" of w [i.e., iteration; cf. G. Temple and W. G. Bickley, "Rayleigh's principle," Oxford Univ. Press, 1933] is greater than the smaller of λ_1^2 and λ_{-1}^2; in general, this approximation also permits a more accurate estimate of the eigenvalue than the original (Rayleigh) approximation in virtue of the improvement in w. It also is shown how the information on which (4) is based can be used to bracket *some* eigenvalue, which is almost always λ_1 unless the next largest eigenvalue (λ_2) is nearly equal (within a limit set by the approximate results) to λ_1. The refinement of this bracketing procedure in terms of a second intensification of w is discussed, as is also the improvement by synthesis of the original w and its first intensification.

The results are applied to the classical problem of the stability of an end-loaded strut and to the stability of a flat plate cantilever that sustains both tensile and compressive stresses. Certain difficulties in the original investigation [D. G. Christopherson, L. Fox, J. R. Green, F. S. Shaw, and R. V. Southwell, *Phil. Trans. roy. Soc.* (*C*) **1**, 57–83, 1949; ibid. (*A*) **239**, 461–487, 1945] of the latter problem are resolved, the details to be discussed in a separate paper. Reviewer believes that the author's results will prove of very great importance in extending the domain of Rayleigh's principle, perhaps the most celebrated of all approximate methods in applied mechanics. J. W. Miles, USA

1357. Sterne, T. E., The accuracy of numerical solutions of ordinary differential equations, *Math. Tables Aids Comput.* **7,** 43, 159–164, July 1953.

Describes a method for estimating round-off and truncation errors in numerical solution of systems of ordinary differential equations. To determine truncation errors, one must obtain a rough solution of the differential equation under study, set up and solve approximately the adjoint of the variational equation corresponding to this differential equation, and find approximately the differential equation corresponding to the integration formula to be used. Example shows how method is used to estimate the interval required to achieve a desired accuracy.

C. C. Gotlieb, Canada

1358. Kito, F., On a property of linear ordinary differential equation, which relates to "end effect" in theory of curved shells, *J. Japan Soc. appl. Mech.* **5,** 30–31, 165–171, Dec. 1952–Jan. 1953.

Let there be given a linear ordinary differential equation of the form

$$A_0(d^n y/dx^n) + A_1(d^{n-1}y/dx^{n-1}) + \ldots\ldots + A_{n-1}(dy/dn) + A_n y = 0$$

where first s coefficients A_0, A_1, A_s have their magnitudes very small compared with the remaining coefficients A_{s+1}, . ., A_n. Such a circumstance occurs frequently in the theory of thin curved shells. In the present paper, it is shown that under such a circumstance there are contained in the general solution just $(s + 1)$ functions of very rapidly varying nature as the independent variable x varies. These $(s + 1)$ functions will represent so-called "edge effect" in the theory of thin curved shells. The argument is based on Volterra's theory of composition of functions.

From author's summary by F. S. Shaw, Australia

1359. Gel'fand, I. M., and Levitan, B. M., Simple identity for eigenvalues of a differential operator of the second order (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **88,** 4, 593–596, Feb. 1953.

Author proves the following theorem: When λ_n are the eigenvalues of the differential equation

$$-y'' + q(x)y = \lambda y$$

with ${}_0\int^\pi q(x)dx \neq 0$ and the boundary conditions

$$-y'(0) - hy(0) = 0; \qquad y'(\pi) + Hy(\pi) = 0$$

and μ_n are the eigenvalues of the differential equation $-y'' = \mu y$ with the same boundary conditions, then

$$\sum_{n=1}^{\infty} (\lambda_n - \mu_n) = \frac{1}{4}[q(0) + q(\pi)] + hH.$$

W. H. Muller, Holland

1360. Green, J. W., An expansion method for parabolic partial differential equations, *J. Res. nat. Bur. Stands.* **51,** 3, 127–132, Sept. 1953.

The problem is to solve $L(u) = u_{xx} - u_t - g(x, t)u = f(x, t)$ in the region $0 \leq x \leq \pi$, $0 \leq t < \infty$ under the conditions $u(x, 0) = u(0, t) = u(\pi, t) = 0$. Assumptions are $g \geq 0$ and the existence of continuous partial derivatives of f and g up to second order. An approximate solution $u_n(x, t) = \sum_{k=1}^{n} C_{nk}(t) \sin kx$ subject to ${}_0\int^\pi [L(u_n) - f]u_n dx = 0$ is set up, leading to a system of first-order differential equations for the C_{nk}. These are solved under the initial conditions $C_{nk}(0) = 0$. Main results are: The problem has one and only one solution $u(x, t)$, and the sequence $u_n(x, t)$ converges uniformly to $u(x, t)$ in any region $0 \leq x \leq \pi$, $0 \leq t \leq T$. u_{nx} and u_{nt} converge uniformly to u_x and u_t, respectively; u_{nxx} tends in the mean to u_{xx}. The proof uses bounds for the integrals ${}_0\int^\pi u_n{}^2 dx$, ${}_0\int^\pi u_{nt}{}^2 dx$, ${}_0\int^\pi u^2{}_{ntt} dx$, ${}_0\int^\pi u^2{}_{nx} dx$, ${}_0\int^\pi u^2{}_{nxt} dx$, and Ascoli's theorem, that out of a uniformly bounded and equicontinuous sequence of functions a uniformly continuous subsequence can be selected. The paper concludes with an estimate of the error of u_n.

It may be mentioned that the existence of one and only one solution of a more general problem has been known for a long time [see Frank-Mises, "Die Differential und Integralgleichungen der Mechanik und Physik," chap. 19, 868–880, 2nd ed., Verlag Vieweg & Sohn A.G., Braunschweig, 1930]. H. Bückner, USA

1361. Howe, R. M., and Haneman, V. S., The solution of partial differential equations by difference methods using the electronic differential analyzer, Proc. Western Computer Conf., Los Angeles, Calif., Feb. 4–6, 1953, 208–226.

1362. Germain, P., and Bader, R., Elliptic and hyperbolic singular solutions of a differential equation of mixed type (in French), *ONERA Publ.* no. 60, 42 pp., 1952.

Three papers written for ONERA in 1949–1950 are here combined for wider publication. The first chapter deals with the existence of a solution of the singular Dirichlet problem for Chaplígin's equation for compressible flow; the adjective "singular" is used to indicate that the boundary on which the values taken by the solution are prescribed contains a segment of the parabolic line separating the domains in which the differential equation is, respectively, elliptic and hyperbolic. In an appendix, the efflux from an orifice of a jet with sonic velocity on the boundary ("le jet critique") is considered. The second chapter is concerned with extensions of the classical problems for hyperbolic equations to the cases where some part of the initial conditions is given on the parabolic line. The equation considered here is a transformation of Chaplígin's equation; it is, in fact, Tricomi's equation with a right-hand side. The method of solution uses the idea of the Riemann function together with Picard's method of successive approximations. D. C. Pack, Scotland

1363. Kestin, J., and Zaremba, S. K., Geometrical methods in the analysis of ordinary differential equations, *Appl. sci. Res. (B)* **3,** 3, 149–189, 1953.

1364. Ödman, S. T. A., Studies of boundary-value problems. Part I. Minimum methods for solving semi-homogeneous boundary-value problems, *Sven. Forskningsinst. Cement Betong Medd.* no. 20, 1953.

1365. Erdélyi, A., Magnus, W., Oberhettinger, F., and Tricomi, F. G., Higher transcendental functions. Vol. I (Bateman Manuscript Project), New York, McGraw-Hill Book Co., Inc., 1953, xxvi + 302 pp. $6.50.

This is the first of a three-volume set which is to be a comprehensive account of the higher mathematical functions. Applied workers are painfully cognizant of the scattered research one must peruse to solve theoretical problems entailing the use of special functions. The late Professor Harry Bateman was one of the greatest authorities on the subject and had planned what would amount to a Greater Oxford Dictionary of the higher transcendental functions. At the time of Bateman's death (1946), his notes were voluminous, His card file, known as the "shoe boxes," occupied several dozen boxes. Recognizing the value of such a study, the California Institute of Technology and the Office of Naval Research united their efforts to continue the task initiated by Bateman. The set is based, in part, on notes left by Bateman. The volume under review and the future volumes will fill a long felt need.

The staff of the Bateman manuscript project was directed by A. Erdélyi, who also served as editor. In this task, Erdélyi had the assistance of W. Magnus, F. Oberhettinger, and F. G. Tricomi, who served as research associates. Several research assistants also participated. The editor remarks that a realistic appraisal of the staff's abilities, available time, and lack of manpower resulted in a drastic revision of Bateman's plans. "Only Bateman himself had the erudition to give a reliable and accurate history of special functions. . . ." Accordingly, the editor and his associates restricted themselves to an account of the principal properties of the special functions considered most important. They realize that

the account is probably much less than that contemplated by Bateman. "The loss thus caused to mathematical scholarship is great, regrettable, and final, but we venture to hope that it will be counterbalanced in some measure by the considerable reduction in size of the book, and by the gain in the clarity of its organization. We can only hope that although the scope of the present work is much narrower than that envisaged by Bateman, in its humbler sphere the book will be more useful."

The set may well be described as an expansion and up-to-date version of part II of the well-known volume "Modern analysis" by Whittaker and Watson. The first volume is divided into six chapters. A list of references is given at the end of each chapter to aid in the location of further material. Though the references are copious, they are admittedly not a bibliography. The table of contents is sufficiently well outlined to facilitate location of items of interest. There is a subject index, and an index of notation is also provided to aid the reader in identifying symbols employed.

Chap. I deals with the gamma function and related items such as the psi function, zeta function, beta function, Bernoulli and Euler numbers and polynomials, etc. The material is quite detailed and documented. Chap. II deals with the hypergeometric function. It is composed of two parts. The first treats the varied theoretical aspects of the function. The second part is a detailed list of formulas. Chap. III is devoted to the Legendre functions. Chap. IV is concerned with generalized hypergeometric series, while further generalizations of the hypergeometric functions are found in chap. V. The volume concludes with a study of the confluent hypergeometric function, chap. VI.

Y. Luke, USA

1366. Erdélyi, A., Magnus, W., Oberhettinger, F., Tricomi, F. G., Higher transcendental functions. Vol. II (Bateman Manuscript Project), New York, McGraw-Hill Book Co., Inc., 1953, xviii + 396 pp. $7.50.

Purpose and history of the set have been given in preceding review. The same general remarks pertaining to indexes, references, etc., apply here. Chapter numbers follow in sequence from vol. I; thus chapters in vol. II are numbered from VII to XIII, inclusive.

Chap. VII deals with Bessel functions and is divided into two parts, theory and formulas. A very brief summary of results available in the standard treatise by Watson is presented, while principal results obtained since publication of latter book (1922) are treated more thoroughly. Watson's notation is followed. Chap. VIII deals with the function of the parabolic cylinder and of the paraboloid of revolution. Chap. IX is a compendium of formulas for the incomplete gamma function and related functions.

Orthogonal polynomials is the subject of chap. X. Here the standard work on the subject by Szegö (1939) is referred to extensively. Principal results obtained since are recorded. Chap. XI takes up the spherical and hyperspherical harmonic polynomials. Orthogonal polynomials in several variables is treated in chap. XII. Chap. XIII is devoted to elliptic functions and integrals.

Y. Luke, USA

1367. Hildebrand, F. B., Note on S. N. Lin's method of factoring polynomials, *J. Math. Phys.* **32,** 2/3, 164–170, July-Oct. 1953.

Paper discusses stability of Lin iterative method for solving polynomials when a single quadratic factor is extracted from given polynomial. Lin technique has been extended by Luke and Ufford [AMR **5,** Rev. 10]. Factorization procedure is called method of penultimate remainder (p.r.) by A. C. Aitken ["On the theory of methods of factorizing polynomials by iterated division," *Proc. roy. Soc. Edin.* **63,** 326–335, 1952], who has given a complete generalization of results of present paper. Aitken studies linear errors produced in coefficients of successive remainders by small errors in coefficients of divisor. It is shown that matrix which effects transformation of errors is a polynomial in rational canonical matrix for which divisor polynomial is characteristic. Aitken gives a procedure for removing linear error, and for a quadratic factor, theory leads to method of Bairstow.

There are in reality two Lin methods. They stand to each other as the Seidelian iteration for solution of simultaneous equations stands to simple iterations. Method of paper and Aitken (p.r.) is simple iteration. Aitken reserves study of other Lin approach as well as related scheme by B. Friedman for separate paper.

Y. Luke, USA

1368. Bose, B. N., On certain theorems in operational calculus, *Bull. Calcutta math. Soc.* **44,** 3, 93–110, Sept. 1952.

1369. Bose, S. K., Some sequences of Laplace transforms, *Bull. Calcutta math. Soc.* **44,** 3, 127–131, Sept. 1952.

1370. Thom, A., The arithmetic of field equations, *Aero. Quart.* **4,** part 3, 205–230, Aug. 1953.

An iteration method is described with examples for the solution of finite difference equations as an approximation to the partial differential equations.

C. T. Wang, USA

1371. Muggia, A., On the calculation of Poisson's integral (in Italian), *Monogr. Lab. Aero. Politecn. Torino* no. 313, 11 pp. = *Atti Accad. Sci. Torino* **87,** 11 pp., 1952–1953.

Author discusses evaluation of ${}_0\int^{2\pi} f(\theta) \cot 1/2(\theta - \theta_0)d\theta$ and gives several tables to facilitate the computations. Principal table gives value of ${}_{-\pi}\int^{t} \theta \cot 1/2\theta d\theta$ to five decimals for $t: -3.12(0.04)4.60$. Tables are useful for calculation of velocity distribution on airfoils. [See also AMR **5,** Rev. 971.]

Y. Luke, USA

1372. Tables of 10^x (Antilogarithms to the base 10), *Dept. of Comm., Nat. Bur. Stands., appl. Math. Ser.* 27, vii + 543 pp. $3.50.

Table I gives item in title for $x = 0(0.00001)1.0$ to 10 D. Linear interpolation gives nine-decimal accuracy. Table II lists $10^{n \times 10^{-p}}$: $n = 1(1)999$; $p = 3(3)$ to 15 D. Historical survey of tables and other pertinent items are discussed in introduction.

Y. Luke, USA

1373. Tomlinson, R. C., A revised index of mathematical tables for compressible flow, *Aero. Res. Counc. Lond. Rep. Mem.* 2691, 12 pp., Dec. 1949, published 1953.

1374. Greinacher, H., Selected problems in experimental physics [Ausgewählte Aufgaben und Probleme aus der Experimentalphysik], 3rd ed., Wien, Springer-Verlag, 1953, ix + 266 pp., 117 figs. $3.45.

1375. Hoelscher, R. P., Arnold, J. N., and Pierce, S. H., Graphic aids in engineering computation, New York, McGraw-Hill Book Co., Inc., 1952, viii + 197 pp. $4.50.

Text is designed for use in a course given by engineering drawing departments to students at the freshman or sophomore level. By graphic aids, authors mean slide rules and nomographic charts. Book is principally devoted to the use and construction of these devices, although a chapter on curve fitting and a chapter on graphical differentiation and integration have also been in-

cluded. Nomographs account for more than half of the work, there being an elementary first presentation followed later by a more general treatment using determinants. Emphasis is on clear, detailed step-by-step directions on how to lay out charts. The style is somewhat reminiscent of culinary literature. Reviewer was troubled by the omission of any discussion of the accuracy of the computational aids treated.

S. H. Crandall, USA

1376. Fleck, J. T., and Fryer, W. D., An exploration of numerical filtering techniques, *Cornell aero. Lab. Rep.* XA-869-1, 79 pp., May 1953.

Numerical filtering is introduced as a method for extending to arithmetic or digital processes the familiar frequency-domain approach of electrical filter theory. For a given linear operation on numerical data in the time domain, the corresponding effect in the frequency domain can be obtained in the form of a filter "transfer function," the term being equivalent in meaning to the transfer function of an electrical filter. Synthesis procedures utilizing the filter concept are capable of generating the classical formulas for numerical operations, and with simple modification can be made to account for noise in the data. Examples of differentiating, integrating, low-pass, and high-pass filters are given. Unique possibilities for the application of numerical filtering in analog systems are suggested and recommendations are made for further development of numerical filtering methods.

From authors' summary

1377. Bulgakov, B. V., Problems of the synthesis of adjusting networks. I, II (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* nos. 1, 5; 21–40, 699–723, Jan., May 1952.

The main idea of the whole work is to consider a symmetric four-terminal, or a line loaded with such four-terminals, having a transmission function which represents arbitrarily closely a given rational function $P(D)/Q(D)$ regular in the closed half plane on the right of the imaginary axis. Especially the elements of the line can be chosen in the manner so as to represent fractional functions with nominator and denominator of zero, first, and second order, whose derivatives are equal to the given function $P(D)/Q(D)$ or differ from it by a constant factor. In part I of the work, the realization of all elements of zero and first order is described. Also a part of elements of second order is treated. In part II, the number of second-order elements is completed and it is shown how to choose the elements in the line to obtain the transmission function which represents the given function $P(D)/Q(D)$. The transmission lines considered by the author contain no self-induction and if possible contain no idealized elements, i.e., inductors without resistances in series and capacitors without conductivity in parallel. So far as idealized elements occur, a second approximation can be used.

J. Beránek, Czechoslovakia

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1389, 1562, 1575)

1378. Hinkle, R. T., Kinematics of machines, New York, Prentice-Hall, Inc., 1953, vi + 231 pp. $4.75.

This book gives an excellent account of the kinematics of machines and their components. Major emphasis is placed on the relative motions of machine parts rather than on the descriptions of mechanisms. Furthermore, the author manages to cover a surprisingly large amount of material, principally due to the concise method of writing and orderly presentation of subject matter.

The first chapters deal with the terminology and basic concepts, equations of motion, velocities in mechanisms, velocity polygons, acceleration and acceleration graphs, and various analytical methods. The presentation is quite lucid and will, indeed, be easily understood by the student with the least possible effort. The author is to be commended for his rhetoric, since far too much time is spent by the student interpreting some writers. As an example, the author states Kennedy's theorem adequately in fourteen words, while other authors have used upward to thirty.

The latter chapters deal with such important items as cams, rolling contact—a necessary preliminary step toward the next topic, the theory of gearing. Then a chapter on belts, chains, and ropes, i.e., flexible connections, followed by a discussion of gear trains, of which automotive transmissions are given as an example. Translation screws are included also in this chapter. The final chapter deals with miscellaneous mechanisms, such as the familiar four-bar linkage. A particularly good discussion is devoted to the universal joint, including the constant velocity types. This is a typical example of the excellent technique used to present the most pertinent data.

This text presents the subject logically and precisely, at all times staying within the boundaries and not straying into the subject of machine design. Many examples and progressively harder-to-solve problems are included at the end of each chapter. This book is undoubtedly an invaluable addition to the field and is highly recommended as a textbook to the engineering student and to those engineers who wish to review the kinematics of machines.

G. B. White, USA

1379. Beyer, R., Analysis of linkages [Kinematische Getriebesynthese], Berlin, Springer-Verlag, 1953, vii + 217 pp. DM 36.

This book is a worthy supplement to the author's "Technische Kinematik" (1931). It presents the more important parts of the work of a seven-page bibliography of papers published in the past 20 years, by many investigators, including the author's own significant contributions. The principal theme is the design of mechanisms to fulfill definite geometrical requirements. As an introduction, the classic theorems of kinematics are derived. These cover the work of Euler, Burmester, Mehmke, Reuleaux, Muller, and others. Except for a few American and English papers, all the references are in German. The addition of English, French, and Russian work especially, would make a better balanced list of the world's efforts. However, many theorems in the text bear the names of their discoverers, and scholarly historical footnotes give proper credit to the originators of whatever national origin. Fortunately, most of the complicated theorems are amenable to graphical and kinematic presentation; analytical mathematics is frequently used but it is never difficult.

A selection of chapter and section headings follows (many of the terms used have appeared previously only in the periodical literature and are given here only because they suggest the scope of the work):

Two positions of a linkage member—two finitely separated positions, two infinitesimally near positions, velocity vector, velocity ratio, Mehmke velocity diagram. Three separate positions of a linkage member—combination of two successive rotations, pole triangle, R_M and R' curves, ordered positions on a line, ordered lines through a point. Crank mechanisms—osculating curves, three infinitesimally near positions, centrode, centrode of antiparallel crank mechanism, Cardan problem, Euler-Savary formula, inflection circle, Bobillier construction for center of curvature, Hartmann investigations, envelopes, return circle, acceleration vector, four-bar linkage, hodograph, ρ-curve. Four separate positions—poles, opposite pole quadrilateral, pole position curve, midpoint curve (Mittelpunktkurve), circle point

curve (Kreispunktkurve), four positions with six poles on a circle, four poles on a line, four ordered lines through a point, four ordered points on a line, other ordered positions, dead centers, ordered positions, and angles. Five separate positions—Burmester points, four and five infinitesimally near positions, crank mechanisms with two rests, pivot point curves (Angelpunktkurve), orthocycloidal motion and approximation, Ball point and applications. Four-bar curves, Robert's law, double points, curves with cusps, parallelograms and antiparallelograms, inversion mechanisms, slide mechanisms, angled slides. Ellipses as osculating curves—six separate positions, gear wheels as intermittent mechanisms. Specified velocities and accelerations—applications to four-bar, relative motion, Coriolis law, Maltese cross mechanism. Cam mechanism—curvature ratios.

There is a short discussion of the Reuleaux three-arc rotor in a square and the two-arc rotor in a triangle. At this point it would have been appropriate to mention the extension to all regular polygons in papers by Meissner and the reviewer ["Über die Anwendung von Fourier-Reihen auf einige Aufgaben der Geometrie und Kinematik," Ernst Meissner, Vierteljahrschrift der naturforschenden Gesellschaft, Zürich, **54**, 309–329, 1909; and "Circular-arc rotors in regular polygons," Michael Goldberg, *Amer. math. Monthly* **55**, 393–402, 1948]. M. Goldberg, USA

1380. **Kinosita, K., Studies in glass-cleaning procedures by static friction measurement,** *J. phys. Soc. Japan* **8**, 6, 782–790, Nov.-Dec. 1953.

The cleaning power of several glass-cleaning procedures is compared in terms of the coefficient of friction of the cleaned surfaces. The author assumes, following Bowden and Tabor [AMR **4**, Rev. 4673], that the coefficient of friction of a surface increases as the amount of oxide vapors or impurities on the surface decreases because of the "lubricant-like" behavior of contaminant films. A friction-measuring device which yields reproducible results, within 1%, is described. Five cleaning procedures are described and each gives rise to a characteristic value of the coefficient of friction μ. The simplest procedure, for example, increases the value of μ(0.3 for naturally contaminated glass) by a factor of 3. The cleanest surfaces (μ increased by a factor of 3.3) are obtained (1) by surface gliding discharge treatment and (2) by flaming. It is interesting to note that overexposure to treatment (1), which produces surface pitting, does not affect the coefficient of friction, thus confirming Bowden's contention that the coefficient of friction is rather insensitive to surface finish. This paper defines a standard for glass cleanliness which will be useful to workers in various fields. E. Koenigsberg, USA

1381. **Rašković, D., Mechanics. III. Dynamics [Mekhanika. III. Dinamika],** Belgrade, Izd. Pred. Narod. Repub. Srbije, 1948, xiv + 459 pp.

As a text of intermediate level, this book gives a maximum return for a minimum of introductory study.

The first chapter describes the fundamental laws of Newtonian mechanics including the general motion of conservative systems. The next chapter deals with general principles of mechanics, such as generalized force systems, generalized coordinates and constraints, introductions to Lagrange's equation, etc. The third chapter is devoted to the translation and rotation of a body about a fixed axis, including Euler's equation of motion, spinning top, gyroscopic effects, and so on. Some fundamental concepts of the potential theory are included in an appendix.

The language of vectors is used extensively. A knowledge of three-dimensional analytic geometry is required. In general, the major objective of this book is to provide an introduction to dynamics for engineering students. The writing is clear and the concepts are easily grasped by the engineering-trained mind. M. M. Stanišić, USA

1382. **Dimitroff, R., Dynamic rules for models by displacement of mass** (in French), *Rech. aéro.* no. 33, 41–45, 1953.

Author presents a convenient method for making dynamic studies of a model. In accordance with usual practice, the products of inertia I_{xy} and I_{yz}, and also y_0, the center of gravity coordinate referred to XOZ, are assumed to be zero. The apparatus described permits varying one of the elements of the ellipsoid of inertia by mass displacement within acceptable limits without changing the others. The underlying theory and the necessary corrections are included. Reviewer recommends this interesting paper to those in the field. Y. K. Jan, Holland

1383. **Castoldi, L., Time derivative of motion function of two systems of deformable coordinates for generalized motion** (in Italian), *R. C. Ist. Lombardo Sci. Lett. Cl. Sci. Mat. Nat.* (3) **15** (**84**), 23–28, 1951.

Let x^i and y^i be two systems of (deformable) coordinates in a 3-space and t the time, so that to any event there correspond a tetrad (x^i, t) and a tetrad (y^i, t), so that a transformation $x^i = X^i(y, t)$ is assigned. The motion of a particle is defined by assigning y^i as functions of t. Then $f(x, t)$ being any assigned function, the derivatives df/dt and d^2f/dt^2 (following the motion of the particle) can be expressed in terms of the derivatives of the y's with respect to t, the partial derivatives of the X's with respect to the y's and t, and the partial derivatives of f with respect to the x's and t. The author works out these formulas and shows how they generalize the Coriolis formula for acceleration and also formulas familiar in the kinematics of continua.

J. L. Synge, Ireland

Gyroscopics, Governors, Servos

1384. **Buland, R. N., Analysis of nonlinear servos by phase-plane-delta method,** *J. Franklin Inst.* **257**, 1, 37–48, Jan. 1954.

Although the synthesis of linear servo systems has been a recognized and standard procedure for the past decade, little progress has been made in the synthesis of nonlinear servos. The application of topological methods, such as the phase-plane-delta method discussed in this paper, to the study of nonlinear dynamical systems with one degree of freedom has, however, achieved some success in particular problems, such as the effect of nonlinear friction on servo behavior. Author describes the geometry of the phase-plane-delta method using a linear second-order differential equation as an example and shows how the method applies to nonlinear equations. Notwithstanding the fact that phase-plane techniques are limited essentially to second-order equations, it is pointed out that higher-order systems can be treated if they can be broken down into a series of first- and second-order equations. Three examples of the application of the method are given. These deal with an on-off rate sensitive controller; a servo system with nonlinear damping; a controller incorporating a device having a linear region and low saturation point. The method may be mechanized to solve equations automatically using an analog computer. A. Porter, Canada

1385. **Fleck, J. T., Interpolation servomechanisms,** *Cornell Aero. Lab. Rep.* UA-624-P-1, 23 pp., 1953.

The purpose of the work covered by the report was to study an interpolation system for generating a continuous output approximating a polynomial input which is observed only at discrete

intervals. The system is particularly applicable to radar track-while-search problems in which the scan interval enforces discrete observations of the target being tracked. The system studied on this project has been in common use in several specific forms, but in no case known to the author has the analysis used in their design followed the concepts described in this report. The study which is discussed is intended to reveal an analytical method for determining transfer relations and stability criteria applicable to the type of interpolation and extrapolation device under discussion, to show how it is possible to establish design criteria from those transfer relations, and to point the way to methods for studying the effects of noise on these systems.

From author's summary

1386. Cunningham, F. W., The present status of automatic control, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-181, 9 pp.

This paper covers the application of automatic control to machine tools, with particular reference to the possibilities of some of the developments of the past few years, many of which are by-products of work that has been done for military purposes.

From author's summary

1387. Boksenbom, A. S., Novik, D., and Heppler, H., Optimum controllers for linear closed-loop systems, *NACA TN* 2939, 27 pp., Apr. 1953.

Authors show a method of finding an equivalent open-loop system for a closed-loop one so that the optimum filter theory developed by Weiner may be applied. Optimumization is based on minimizing mean-square or integral-square error for either stationary, statistical, or transient inputs, with limits and constraints of the same form as the error. This treatment allows a more general approach of optimumization since the entire frequency-response characteristics rather than certain parameters of the controller are adjusted. A generalization extending the treatment from one to many variables is given and special solutions noted. Experimental results show substantial agreement with theory.

This reviewer does not agree with authors' remark (p. 7) that ". . . the proper discussion of stability should deal only with stable structures." A. C. Block, USA

1388. Capriz, G., Precession of a gyroscope with asymmetrical armature (in Italian), *R. C. Mat. appl.* (5) **7**, 1/2, 229–236, Jan.-June 1953.

Author considers a heavy system S_4 of four degrees of freedom built by: (1) An armature S' of mass m' and center of mass G', fixed to a point O, different from G'; (2) a gyroscope S, of mass m and center of mass G, the axis of which is fixed at S', passes through O and not through G'. Author studies all the motions of S_4, which correspond to a uniform rotation of armature around a fixed axis which passes through O. The results complete those obtained by A. Signorini, when O, G, and G' are aligned [*Ann. Mat. pura appl.* (4) **24**, 1950]. J. N. Aguirre, Argentina

1389. Grioli, G., On the dynamics of the heavy asymmetric solid (in Italian), *R. C. Semin. mat. Univ. Padova* **21**, part 2, 256–277, 1952.

Author investigates the possible dynamical motions which can be performed by a heavy asymmetric solid C^* of weight mg, baricenter G, angular velocity ω, and total energy E_0 attached without friction at a point O. In the first instance those motions were studied where the kinetic moment with respect to O maintains a constant direction, and where it is the sum of two terms $K = K_1\chi + K_2\mathbf{i}_3$, both maintaining constant direction, χ in space and $\mathbf{i}_3$ in the body; K_1 and K_2 being scalar functions of time.

These motions exist in the case of the heavy gyroscope, fixed without friction at a point of the gyroscopic axis, and are precessions or, in particular, rotations. The asymmetric solid performs motions obeying these conditions: uniform rotations around the vertical of unit vector μ, and nonuniform Mlodezjejowski motions around the principal inertia axis of horizontal direction.

Author demonstrates that those motions, designated as regular precessional, where $\mathbf{K}$ is the sum of two terms—one constant in space and the other in the body—are dynamically impossible. Writing $\alpha = mg\,|OG|$, and μ_3, r for the components of μ and ω on $\mathbf{i}_3$, it is shown, first, that, if $\beta = \mu_3 + rK_2/\alpha$ is constant, the eventual motion of C^* cannot depart from a uniform rotative motion around the vertical, and, second, that when $H = K\mu + 2K_2(\alpha\mu_3 + E_0)/\alpha$ is zero, the eventual movement of C cannot depart from rotation. When $\mathbf{K}$ is the sum of two terms, one of constant direction in space and the other of constant direction in the body, $\mathbf{K}$ is described as being of precessional character. If the sole condition is that the direction of $\mathbf{K}$ is constant in space, it is shown that the set of motions obeying this condition—excluding the uniform rotations around a central axis—is a Hess class, consisting in irregular precessions and, especially, nonuniform rotations.

Later on it is demonstrated that these irregular precessions of the heavy asymmetric solid are a composition of a Mlodezjejowski motion and a motion of rotation around a baricentral axis, with the result that these precessions are determined by exponential functions if, and only if, $E_0 = \alpha$.

R. R. Hunziker, Argentina

Vibrations, Balancing

(See also Revs. 1512, 1521, 1562)

1390. De Castro, A., About the nonlinear oscillation of a system with one or more degrees of freedom (in Italian), *R. C. Semin. mat. Univ. Padova* **12**, part II, 294–304, 1953.

Author considers the equations

$$\ddot{x} + f(x, \dot{x}, t) + g(x) = 0$$

and the system of differential equations

$$\ddot{x}_1 + f_1(x_1, \dot{x}_1, x_2, \dot{x}_2, t) + g_1(x_1) = 0$$

$$\ddot{x}_2 + f_2(x_1, \dot{x}_1, x_2, \dot{x}_2, t) + g_2(x_2) = 0$$

$f(x, \dot{x}, t)$, $f_1(x_1, \dot{x}_1, x_2, \dot{x}_2, t)$, $f_2(x_1, \dot{x}_1, x_2, \dot{x}_2, t)$ are periodic functions of t of period T. He proves that [1] and [2] have periodic solutions of period T. He proves also that the system

$$\ddot{x}_1 + f'(x_1, \dot{x}_1, x_2, \dot{x}_2) + g_1(x_1) = 0$$

$$\ddot{x}_2 + f''(x_1, \dot{x}_1, x_2, \dot{x}_2) + g_2(x_2) = 0$$

has periodic solutions. He supposes the mechanical systems performed by the equations [1], [2], [3] are dissipative for large values of $|x|$ or $|\dot{x}|$ or both, except the case $x\dot{x} < 0$ and $|x|$ limited. D. Graffi, Italy

1391. Liénard, P., Graphical representation of an oscillator, useful for the study of nonlinear systems (in French), *Acustica* **3**, 4, 212–223, 1953.

See AMR 6, Rev. 1503.

1392. Trabucco, L., Method of tuning curves, applied to the study of natural frequency of torsional vibrations (in Italian), *ATA* **5**, 3, 169–178, March 1952.

1393. Cohen, G., and Carrier, G. F., Subharmonic synchronization for the forced van der Pol equation (French and English), *Publ. sci. tech. Min. Air, Paris* no. 281, 169–187, 1953.

Using method of Poincaré, the van der Pol equation for small parameter is shown to admit solutions containing subharmonic of forcing frequency when it is sufficiently close to natural frequency. Quantitative measures of amplitude of subharmonic and range of variation of forcing frequency to permit this phenomenon are obtained. Stability criteria for above solutions are also derived.

L. Becker, USA

1394. Kirby, P. L., A method of examining the transverse vibrations of rods and reeds, *Brit. J. appl. Phys.* **4,** 9, 279–281, Sept. 1953.

Apparatus is described with which the vibrations of a thin rod or reed are transformed by means of a capacity-type electromechanical transducer into varying electrical potentials. These are recorded and the damping constants are determined. In case of rods of nonconductive materials, the specimens are coated with a thin layer of gold or silver. R. O. Fehr, USA

1395. Ghosh, S. K., Dynamics of the vibration of a bar exhibiting strain-rate effect under conditions of longitudinal impact, *Indian J. theor. Phys.* **1,** 1, 25–40, June 1953.

This paper is a continuation of two papers [AMR **5,** Rev. 354; AMR **6,** Rev. 2174] by the author in collaboration with M. Ghosh on longitudinal impact. The impinging body is an elastic solid of mass m and Young's modulus E. The impacted body is a thin bar of viscoelastic material which obeys the (stress, strain) relationships for a linear Voigt solid; the bar is fixed at the end remote from the impact. The solutions are obtained by the operational method and they fall into four classes determined by the values of m, E_2, and the density and Young's modulus of the material of the bar. Assuming that squares and higher powers of the viscosity of the material of the bar can be neglected, expressions are derived for the time variation of the displacement and the force at the struck end of the bar during impact.

R. M. Davies, Wales

1396. Gröbner, W., and Lesky, P., The natural vibrations of an annulus of rectangular cross section (in German), *Öst. Ing.-Arch.* **7, 3,** 254–262, 1953.

The natural vibrations of an annulus of rectangular cross section have already been ascertained in a classical manner by K. Federhofer on basis of the plane strain. But the numerical exploitation of these exact results is extremely wearisome. For this reason, the present report deals with the same problem, approaching it according to a different method which, though being less exact, permits establishing a handy formula for the vibration frequencies by way of a relatively slight amount of calculation. The method employed in this connection is a generalization of the well-known method of Ritz and is based on a direct exploitation of the Hamilton principle. Furthermore, this method offers the advantage of not being limited to the plane strain, but of being applicable without great difficulties also to the three-dimensional problem with marginal conditions of any kind.

From authors' summary by R. G. Boiten, Holland

1397. Egger, H., Calculation of natural vibrations of beam-spring-and-mass system (in German), *Öst. Ing.-Arch.* **7, 3,** 188–214, 1953.

Three lowest natural frequencies of a built-in cantilever and of a free-free beam, each with elastically attached mass, are computed for wide ranges of the parameters involved. Response to a sinusoidally varying point load is also discussed. Equations of motion are obtained from the kinetic and potential energies by the methods of Lagrange. The analysis is given clearly and in detail. C. M. Ablow, USA

1398. Heaps, N. S., The vibrations of a swept wing, *Aero. Res. Counc. Lond. curr. Pap.* 141, 20 pp., 6 figs., Apr. 1952, published 1953.

The effect on the modes and frequencies of a swept wing with ribs parallel to the direction of flight and with a built-in skewed root section is considered theoretically. Coupling between bending and torsion which arises from the skewness of the ribs is considered along with the stiffening effects which arise from the introduction of the skewed ribs into the structural geometry. The conclusions of the paper may be summarized as follows: (1) The effect of the rib coupling on the frequencies is small for the fundamental modes. The changes in frequency, due to the increased stiffness which arises from the skewed ribs may, however, be significant. (2) The effect of the coupling between bending and torsion arising from the built-in skewed root section becomes greater as the sweep increases; however, for sweep angles less than about 50° this effect is small. J. E. Stevens, USA

1399. Shevloff, N. P., and Reid, T. J., The normal modes of vibration of an aircraft, *Aircr. Engng.* **25,** 298, 360–366, Dec. 1953.

Using the lumped-mass approximation, eigenvalue equations for the vibration of an aircraft are given in a very general matrix form. Y. C. Fung, USA

1400. Ledinegg, E., and Urban, P., Determination of elastic constants of isotropic solid bodies by ultrasonics (in German), *Acta Phys., Austr.* **8,** 1, 16–27, 1953.

Authors solve problems of a solid cylindrical rod or disk immersed in a fluid contained in a coaxially disposed, finite, hard-walled right cylindrical container. Exact expressions are derived for the secular equations determining dilational eigenfrequencies. Assuming rod diameter small compared to cylinder diameter (or disk height much less than cylinder height), approximate expressions are obtained for shift of gravest frequency of liquid cylinder upon introduction of solid. Experimental confirmation is promised in a later paper. V. Salmon, USA

Wave Motion, Impact

(See also Revs. 1655, 1659)

1401. Keller, J. B., and Weitz, M., Reflection and transmission coefficients for waves entering or leaving an icefield, *Comm. pure appl. Math.* **6,** 3, 415–417, Aug. 1953.

Authors obtain two sets of formulas for the reflection and transmission coefficients for waves entering or leaving an ice field. The first set applies to water which is deep compared to the wave length, and the second to water which is shallow compared to the wave length. E. J. Scott, USA

1402. Woods, L. C., A relaxation treatment of shock waves, *Aero. Res. Counc. Lond. curr. Pap.* 134, 9 pp., July 1950, published 1953.

A procedure for using a relaxation method to determine the strength and location of shock waves in two-dimensional transonic flow is described. No examples are given.

K. C. Harder, USA

1403. Sakurai, A., On the propagation and structure of the blast wave, I, *J. phys. Soc. Japan* **8,** 5, 662–669, Sept.-Oct. 1953.

The propagation and structure of plane and cylindrical blast waves are investigated by methods similar to those used by Taylor [AMR **4,** Rev. 1381] for spherical waves. Assumption is made that blast wave is produced only by the sudden release of finite amount of energy of infinite density. Numerical and approximate solutions are presented for very strong waves where terms involving $(c/U)^2$ and higher terms can be neglected (c is velocity of sound in undisturbed gas and U is shock velocity). Also specific heat ratio is assumed constant throughout the calculations.

R. E. Duff, USA

1404. Taylor, J., Landing of an aircraft on a suspended sheet, *Aero. Res. Counc. Lond. Rep. Mem.* 2574, 37 pp., June 1947, published 1953.

An investigation is made into the characteristics of a freely suspended flexible sheet as a shock absorber replacing the conventional undercarriage, particular attention being given to the inertia of the sheet. It is found that when an aircraft is dropped vertically onto the sheet the retarding force is first produced by the inertia of the sheet itself, and not until later in the descent by the reactions from the side supports of the sheet. By careful adjustments of the mass and tension of the sheet, "retardation efficiencies" exceeding 80% can be achieved. The effect of the aircraft having a forward component of velocity increases the contribution of sheet momentum.

From author's summary by R. F. Smiley, USA

Elasticity Theory

(See also Revs. 1416, 1425, 1426, 1445, 1447)

1405. L'Hermite, R., Strength of materials. Theoretical and experimental. Vol. I. Elasticity theory for elastic structures [Résistance des matériaux. Théorique et expérimentale. T. I. Théorie de l'élasticité et des structures élastiques], Paris, Dunod, 1954, xvi + 860 pp., 384 figs. 8400 Fr.

Subjects covered are: Theory of elasticity; plane elasticity; internal equilibrium of bodies, one of whose dimensions is great with respect to the other two (e.g., beams); tension and flexure; torsion; theory of statically determinate structures; statically determinate straight, curved, and hinged members; theory of statically indeterminate structures for beams and systems of straight members, also for curved beams, arches, rigid frames, and three-dimensional structures; plates and slabs in flexure; thin shells, including prismatic plate structures. Very thorough treatment is given in the fields of theory of elasticity, advanced mechanics of materials, and of plates and shells. In the field of statically indeterminate structures a general survey is made and then complete development is given for topics such as horizontally curved beams and beams on elastic supports. Notation is listed at the end of each chapter. More than 700 references are listed at the ends of chapters in addition to many more footnotes.

Reviewer believes book to be the best documented piece of work in its field and should be accessible to all those engaged in machine design, structural and aeronautical stress analysis, and in the field of theoretical and applied mechanics.

R. B. Moorman, USA

1406. Kappus, R., Determination of the condition of stress from measured strains by means of the Mohr circle and its pole (in French), *Rech. aéro.* no. 33, 47–50, 1953.

Paper describes a simple and elegant graphical method for solving title problem when direct strains are known in three or more arbitrary directions. Method uses little known property of Mohr circle and, in the case where more than three strains are given, it provides a ready check on the isotropy of the material strained.

P. C. Dunne, England

1407. Bressan, A., On the deformations of crystalline, cylindrical bodies according to the theory of Saint-Venant, *R. C. Semin. mat. Univ. Padova* **12,** part II, 281–293, 1953.

Author considers simple extension, torsion, uniform and nonuniform bending of bars that are anisotropic with three planes of symmetry, and asks whether the same states of stress and deformation can exist in isotropic bars. He finds that it is or is not possible, depending upon whether certain relations between elastic coefficients are satisfied.

G. W. Housner, USA

1408. Bland, D. R., Mean displacements on the boundary of an elastic solid, *Quart. J. Mech. appl. Math.* **6,** part 3, 379–384, Sept. 1953.

In this paper the calculation of mean strains is treated by a method similar to that of Betti. The use of the method is extended to a class of problems not previously treated. The fundamental theorem required is proved directly instead of as a deduction from the reciprocal theorem.

W. M. Shepherd, England

1409. Deresiewicz, H., Contact of elastic spheres under an oscillating torsional couple, *J. appl. Mech.* **21,** 1, 52–56, Mar. 1954.

Two elastic spheres are in Hertz contact under compressive forces N directed along their common normal. About this normal a torsional couple M is applied to each sphere, holding N constant. E. Reissner and H. F. Sagoci [*J. appl. Phys.* **15,** p. 652, 1944] first solved the mixed boundary-value problem which may be formulated in the absence of slip on the circular contact surface. Author erroneously credits this solution to R. D. Mindlin, who, however, extended Reissner and Sagoci's result to more general geometric configurations [AMR **3,** Rev. 2592]. See also Sneddon, "Fourier transforms" [AMR **4,** Rev. 3753].

The solutions without slip on the interface find that no additional normal traction arises and that the tangential traction becomes infinite on the boundary of the contact surface. Hence the smallest moment M must give rise to slip on the contact surface. Reviewer studied this problem with allowance for slip [AMR **4,** Rev. 4402]. Author modifies reviewer's complicated relation between M and the rotation β of the contact surface to a manageable approximate form valid for small twists. (Reviewer's tabular values for M, labeled "exact" by author, may contain some errors of a few tenths of a per cent, judging from author's calculations.) Purpose of this modification is to obtain an explicit moment-twist relation so that, still holding N fixed, the effects of further changing M may be investigated. As in similar studies, in which tangential forces were superimposed on a constant Hertz force [AMR **6,** Rev. 3659], a procedure is first devised for reducing M from some value initially attained (unloading procedure). Because the basic moment-twist relation is nonlinear, the net rotation β of the adhered or slip-free portion of the contact surface depends on the previous history of loading, as well as the current magnitude of M. Author shows how to allow for counterslip during unloading, and gives formulas for calculating the tractions, radius to which countership penetrates, rotation of the adhered portion of the interface, and loading and unloading compliances. A moment-twist hysteresis loop is then constructed by oscillating M between fixed limits $\pm M^*$, still holding N constant. The frictional energy loss per cycle varies

as the cube of M^*, for small M^*. In the case of an oscillating tangential force superimposed on Hertz contact, the loss per cycle also varies as the cube of the peak force T^*, for small T^*.

J. L. Lubkin, USA

1410. **Eubanks, R. A., Stress concentration due to a hemispherical pit at a free surface,** *J. appl. Mech.* **21,** 1, 57–62, Mar. 1954.

Paper contains a solution in series form for the stresses and displacements around a hemispherical pit at a free surface of an elastic body. The problem is idealized by considering a semi-infinite medium which otherwise is bounded by a plane. At infinity the body is assumed to be in a state of plane hydrostatic tension perpendicular to the axis of symmetry of the pit. The present method of solution may be generalized to loadings which are not rotationally symmetric. Numerical results are given for the variation along the axis of symmetry of the normal stress which is parallel to the tractions at infinity; these results are compared with the known corresponding numerical values appropriate to the two-dimensional analog of the present problem.

From author's summary

1411. **Paslay, P. R., and Plunkett, R., Design of shrink fits,** *Trans. ASME* **75,** 7, 1199–1202, Oct. 1953.

An analysis is made of the displacements and forces in a shrink fit. Tests on samples showed that the push-off forces are greater than by-force fits. The torque capacity is correspondingly greater. With the given curves a design method is presented.

C. R. Freberg, USA

1412. **Parkus, H., Thermal stress in pipes,** *J. appl. Mech.* **20,** 4, 485–488, Dec. 1953.

An incompressible hot liquid in steady-state flow enters at one end of an infinitely long tube of inner radius a and outer radius b, at an initial temperature. Heat is transferred from the flowing fluid to the surrounding tube, its outer surface being kept at constant temperature. Within $a \leq r \leq b$, the solution of equation of steady-state heat conduction $V^2T = 0$, where T is the temperature excess of the tube over ambient temperature, has been constructed by means of Bessel functions of zero order of first and second kind so as to satisfy conditions of temperature on the boundary, $r = a$, $r = b$. On introducing thermoelastic potential [cf. "Theory of elasticity" by S. Timoshenko and J. N. Goodier], thermal stresses are obtained which, of course, give rise to certain stresses on the boundary. The boundary, however, is then made free from stress by the addition of extra terms obtained on the hypothesis that there is no temperature distribution.

D. N. Mitra, India

1413. **Belov, A. V., Temperature conditions of the surrounding medium resulting in given stresses on the surface of a concrete slab** (in Russian), *Gidrotekh. Stroit.* no. 2, 19–24, 1953.

Temperature stresses at every point in a slab of arbitrary shape and fixed on the contour are given by Galerkin for temperature differential in plane of, but not through thickness of slab. Inability of slab to expand and contract under temperature differential in thickness produces axial and bending stresses. Former are uniformly distributed along depth and boundary and are proportional to temperature differential at middle surface; and latter are uniformly distributed along boundary and linearly along depth. The sum of these three gives expression for stresses in the fixed slab. Putting equal and opposite actions at the boundary caused by temperature differential in thickness (after Saint Venant), temperature stresses are obtained in the free slab.

Author gives method for finding necessary constants, and procedure in applying theory to practice is given by means of an example.

S. Sergev, USA

Experimental Stress Analysis

(See Revs. 1479, 1480)

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1394, 1397, 1457, 1630)

1414. **Thomson, W. T., and Rogers, T. A., Analog solution for beams excited by an arbitrary force,** *J. appl. Mech.* **20,** 4, 482–484, Dec. 1953.

Using the Bernoulli-Euler equation for the motion of a beam and the method of normal functions, the deflection of a specified point along the beam can be expressed in the form

$$y(t) = \Sigma A_i D_i$$

where A_i is a coefficient which can be calculated and D_i is the solution of the differential equation

$$\ddot{D}_i + \omega_i^2 D_i = \omega_i^2 f(t)$$

In the above equation ω_i is the circular frequency of the i-th mode and $f(t)$ is the time variation of the applied force.

A photoelectric wave-form generator is used to generate $f(t)$. Each desired D_i is obtained by simulating the differential equation on an electronic analog computer of the operational amplifier type, and the output fed through a potentiometer set at the value of A_i. The voltages representing A_iD_i for each of several modes are added by a summing amplifier and the result is fed to a recorder.

The purpose of the analog procedure is simply to avoid the numerical calculation of D_i when $f(t)$ is of such a form that a simple solution cannot be obtained analytically.

D. Young, USA

1415. **Rieve, J. J., Stability of I-beams loaded with concentrated forces** (in German), *Bautech.-Arch.* no. 7, 3–32, 1953.

Part I of the paper, using Airy's function and Fourier's theorem, determines the state of plane stress in a web of an I-beam caused by single forces acting upon the flanges. (Relevant approximate formulas are given later.) The instability problem of the web is then treated by the Ritz method, where four terms seem to give satisfactory results. Then the combination of the direct stresses (part I) and bending stresses is dealt with, a simple graph illustrating a numerical example. The last part describes experiments which are partly in agreement with theoretical results.

K. Marguerre, USA

1416. **Gerstle, K. H., and Clough, R. W., Torsional rigidity of rectangular slabs,** *J. Amer. Concr. Inst.* **25,** 3, 241–248, Nov. 1953.

Analysis of many three-dimensional monolithic structures requires information as to the torsional rigidity of the elements of which they are constructed. Because of rigid connections at the ends, warping of the members is restricted and bending stresses are induced with the torsion. For this reason, the elementary theory of torsion cannot be applied. In this paper, the effect of end restraint on the torsional rigidity of rectangular slabs has been analyzed. The magnitude of the stiffening effect is found to vary with the length-width ratio of the slab. For square slabs, end fixity increased the rigidity by 80%. Even for slabs with length-width ratios of 6, the rigidity is increased by 8%. Ex-

perimental data are also presented, showing good agreement with the analytical results. From authors' summary

1417. Federhofer, K., Elastically supported circular ring beam loaded perpendicularly to its plane (in German), *ZAMM* **33,** 8/9 292–293, Aug./Sept. 1953.

Using strain-energy method, author derives differential equations for displacements of a circular ring beam where the supporting medium exerts resistance both to perpendicular displacement and twisting. For details, reference is made to author's contribution to the von Mises Anniversary Volume.

J. Hult, Sweden

1418. Bleich, H. H., and Salvadori, M. G., Impulsive motion of elasto-plastic beams, *Proc. Amer. Soc. civ. Engrs.*, **79,** Separ. no. 287, 25 pp., Sept. 1953.

Motion is analyzed in terms of normal modes of elastic parts of beam. An upper bound to the plastic angle is obtained by a rigid-plastic approximation. A numerical illustration is included.

C. M. Ablow, USA

1419. Gercke, M. J., Collapsing load of a strut with elastically-fixed ends, *Engineering* **176,** 4564, 67–70, July 1953.

Long column expression is derived for columns whose ends are hinged elastically and restrained to relative lateral motion by an elastic resistance. Author names basic dimensionless group of column analysis Pl^2/EI "specific collapsing load," which in usual analysis equals π^2 times fixity factor. From this, the equivalent pin-ended buckling length is readily obtained, or the breakdown load of a rigid strut due to lateral end shifting. Analysis permits column fixity to be defined in terms of the elastic properties of surrounding structure and, although limited to long columns, method could probably be extended to the more usual short columns without great difficulty.

C. M. Tyler, Jr., USA

1420. Bolotin, V. V., Integral equations of constrained torsion and stability of thin-walled rods (in Russian), *Prikl. Mat. Mekh.* **17,** 2, 245–248, Mar.-Apr. 1953.

Author transforms the differential equation for a thin-walled rod, derived by V. Z. Vlasov, into an integral equation which can be solved by successive approximations or by approximate integration. The report contains integral equation for stresses in the case of constrained torsion and for stability of plane form of bending for a rod with sections symmetrical to two axes, if the load acts in the flexural center. Z. Bažant, Czechoslovakia

1421. Capildeo, R., Flexure with shear centres: A general treatment with complex variable, *Proc. Camb. phil. Soc.* **49,** part 2, 308–318, Apr. 1953.

The Saint Venant flexure problem for a beam of arbitrary cross section is formulated through use of the complex torsion function introduced by Stevenson [*Phil. Mag.* (7) **39,** p. 297, 1948]. Using methods followed by Stevenson, it is shown that the center of flexure, center of least strain, and the associated twist are expressible in terms of the complex torsion function. Results are specialized for simply connected cross sections mapped on the unit circle by a power-series mapping function. Center of flexure for the elliptic limaçon is evaluated, indicating an error in the result previously obtained by Stevenson [*Proc. Lond. math. Soc.* (2) **45,** p. 126, 1939]. Paper concludes with application of the method to doubly connected cross sections mapped on a circular annulus by a power-series mapping function, following closely the work of Stevenson for the torsion problem. Center of flexure for an eccentric circle cross section is obtained, agreeing with result previously obtained by Stevenson [*Proc. Lond. math. Soc.* (2) **50,** p. 536, 1948] using flexure functions. Determination of the center of flexure for an annulus bounded by elliptic limaçons indicates that the contribution of the term containing Poisson's ratio is not negligible, as has been the case for other cross sections whose solutions are known. K. S. Pister, USA

1422. Solaja, V., The problem of the minimum number of teeth in the gear train of a gearbox (in Croatian), *Masinstvo i Elektrotehnika* no. 5, 1247–1250, 1952.

An attempt is made to solve the following problem: Ascertain the minimum sum of teeth Z in a gear train with n pairs of meshing gear wheels between two shafts, for which the true transmission factors k are within prescribed limits. An analysis of the absolute differences Δ_z between the calculated numbers of teeth z_m and z_v (usually fractional numbers) and actual numbers of teeth z_M and z_V (whole numbers) indicated the dependence of these differences Δ_z on the transmission factors k, the allowed error in these transmission factors (i.e., revolutions per minute) Δ in per cents, and the sum of the number of teeth Z. It was proved that the smallest common number Z is the smallest common solution of n intervals. A diagram is proposed for practical use.

From author's summary by A. O. Schmidt, USA

Plates, Disks, Shells, Membranes

(See also Rev. 1358)

1423. Woinowsky-Krieger, S., On bending of a flat slab supported by square-shaped columns and clamped, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-60, 8 pp.

A solution is given in this paper for the problem of bending of an infinite flat slab loaded uniformly and rigidly clamped in square-shaped columns arranged to form the square panels of the slab. The complex variable method in connection with conformal mapping is used for this aim. Although not perfectly rigorous, the solution obtained is sufficiently accurate for practical purposes and, besides, it can be improved at will. Stress diagrams traced in a particular case of column dimensions do not wholly confirm the stress distribution, generally accepted in design of flat slabs. From author's summary by M. Botman, Holland

1424. Levin, E., On reinforced circular cutouts, *J. appl. Mech.* **20,** 4, 546–552, Dec. 1953.

A slab with a reinforced circular cutout is subjected to a load that would give a state of pure tension in a full plate. The cross section of the reinforcement may have an arbitrary form, and, in this respect, paper is an extension of work of Weiss, Prager, and Hodge [AMR **6,** Rev. 803], who only considered cutouts with rectangular cross section. The material is perfectly plastic ($\tau \leq \tau_s$). A lower boundary of the collapse load is determined by the aid of the theorem that states that a given system of loads on a structure of a perfectly plastic material does not cause collapse if stresses can be found that (a) are in equilibrium with the given loads and (b) do nowhere exceed the yield limit.

Only states of stress that leave the slab outside of the reinforcement in the homogeneous state of stress are considered, and that is the reason the reviewer thinks that the obtained lower boundaries may be of little value (vanishing cross-sectional area of reinforcement, e.g., $H = 0$ or $\delta = 0$ in eq. [39], gives vanishing load, which is, of course, far too pessimistic). The method is, however, suitable to design full-strength reinforcements. Four full-strength reinforcements with different cross-sectional shapes are compared numerically. J. P. Benthem, Holland

1425. Higuchi, M., The stresses in the orthotropic semi-infinite plate due to a rigid bolt pressed against its edge, *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **2,** 6, 39–52, June 1953.

Author presents a solution for the stresses induced in an orthotropic semi-finite plate by pressing a rigid body against the plate edge. The solution is obtained in terms of coefficients in the series expansion of the edge stresses, which coefficients may be obtained by equating the corresponding edge displacements and the function describing the rigid body shape. All equations refer to a material with arbitrary orientation of the axes of orthotropy.

In general, the solution will be complex. For the case of a plate fastened to a rigid straight die that is pushed and/or twisted, and for a plate that is compressed by a rigid die of parabolic shape (an approximation of a circular body), the solutions are relatively simple, results being obtained in finite terms. In all of these cases, slipping between the plate and die is unrestrained. Author also presents an incorrect solution for the plate compressed by a rigid straight die with slipping totally restrained.

The method used appears to be that of Muskhelishvili applied to orthotropic media. Unfortunately, the paper is very difficult to read since the author does not expound on his method and does not define many of his symbols, leaving the deduction of the probable method of attack to the ingenuity of the reader.

P. Seide, USA

1426. Higuchi, M., On the stresses due to pressure on the periphery of the hole in an orthotropic plate, *Rep. Res. Inst. appl. Mech., Kyushu Univ.* **2,** 6, 53–64, June 1953.

Theory presented in a previous paper [AMR **3,** Rev. 2211] is used to determine stress distribution for several cases of applied distributed pressures and concentrated forces on the periphery of a hole in an orthotropic plate. Curves are given for stress distribution for the case of a circular hole with uniform distributed pressure on the boundary and for a uniform radial expansion.

M. V. Barton, USA

1427. Werren, F., and Norris, C. B., Mechanical properties of a laminate designed to be isotropic, *For. Prod. Lab. Rep., U. S. Dept. Agric.* 1841, 26 pp., May 1953.

This report presents the results of 36 compression tests and 24 flexural tests of a laminated panel made of orthotropic laminations but designed to be isotropic in the plane of the laminate. The panel was made of a glass fabric and a polyester resin. Tests at various angles of loading showed that the laminate was isotropic in both elastic and strength properties.

The mathematical development leading to the design of the test laminate is given in the appendix. Also included are equations for predicting the elastic and strength properties of isotropic laminates from the properties of the individual laminae.

From authors' summary

1428. Fuchs, S. J., Plates with boundary conditions of elastic support, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 199, 24 pp., June 1953.

A solution for the symmetrical bending of a thin rectangular plate whose edges are rigidly joined to supporting beams is formulated. The complementary solution consists of the even function of Levy's series and the same function with the Cartesian axes rotated through a 90° angle. A particular integral has to be chosen for each loading condition. The coefficients in the series can then be uniquely determined by the boundary conditions which are expressed in terms of the ratios λ_1 and λ_2 of the flexural rigidities of the beams to the plate and the ratios κ_1 and κ_2 of the torsional rigidities of the beams to the flexural rigidity of the plate. Such determinations are carried out for a simply, flexurally supported plate (i.e., $\kappa_1 = \kappa_2 = 0$, λ_1 and λ_2 finite) under uniform load. Numerical evaluations are made by taking ten terms in each series and are presented in graphs of various moment and reaction coefficients for square plates with $\mu = 0.15$ over the full range of $\lambda_1 = \lambda_2$. For the limiting case of $\lambda_1 = \lambda_2 \to \infty$ (non-flexural support), the solution can be reduced to the classical one of Levy. It is shown that there also exists a particular set of values of λ_1 and λ_2 for which the expressions for moment and reaction reduce to simple exact formulas. Two introductory tests made on panels supported on beams of finite flexural rigidity show about 10% average deviation of the strains with respect to the corresponding theoretical values.

The formulation for the symmetrical case can be extended to the antisymmetrical or general plate conditions. Reviewer notes that one would use the odd function or the general form of Levy's series. The process of superposition of component solutions referred to successively rotated Cartesian axes may be extended to the construction of a formal solution for the general polygon.

G. C. K. Yeh, USA

1429. Pozzati, P., Contribution to the study of shells of revolution (in Italian), *G. Gen. civ.* **91,** 5, 249–258, May 1953.

The work consists of two parts. I. After giving in a general way the elastic coefficients of a shell of revolution (displacement and rotation of edge through a force $H_e = 1$ and a moment $M_1 = 1$), author defines the stiffness W to rotation and the stiffness T to translation, for the edge of the shell as well as for the ring, then expresses the moments and the thrust as functions of the preceding elements and gives at once the same formulas for perfect clamping. Finally, he outlines the deduction of coefficients k which take account of elastic displacement and rotation of the edges. He concludes with two examples, the second of an Intze tank, to show the advantage of the method which permits analysis of the whole without solving systems of equations.

II. In this part, the analogy between the simplified equations of Geckeler and those of a beam on elastic foundation are studied, to the effect that the meridian fringe may be replaced by a fictitious beam of infinite length with constant modulus of foundation, which makes it possible to use, for shells, the already known tables of functions of said beam. The ideas about stiffness in shells of revolution have already been expressed by O. Belluzzi [*Sci. Costr.* **III,** chap. XXVIII, p. 395]. Author applies them to structures consisting of several shells without using systems of equations, which saves calculation work.

Paper is an interesting contribution to simplification of shell-bending calculations. A. M. Guzmán, Argentina

1430. Hruban, K., Long cylindrical shells of reinforced concrete (in Czech), Anniv. Vol., Zdeněk Bažant, Praha, Technic.-Veděc. Vydavat., 119–142, 1952.

An approximate method for solving stress and strain in long cylindrical reinforced-concrete shells by omitting those terms in the calculation whose contribution to the total deformation is negligible. Author states that his solution does not agree with that of Flügge and Dischinger and indicates the probable reason for the discrepancy of results. M. Hampl, Czechoslovakia

1431. Thürlimann, B., Bereuter, R. O., and Johnston, B. G., The effective width of a circular cylindrical shell adjacent to a circumferential reinforcing rib, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 347–356, 1952.

In a thin, circular cylindrical shell reinforced by a circumferential rib, a portion of the shell will act effectively with the rib to

form a ring that resists load applied externally or induced by the shell. It is shown that the width of this ring, termed the "effective width," depends on the shell radius, shell thickness, circumferential stress distribution, and amount of overhang to a free edge. The concept of an effective width is used to calculate the stress resultants, stress couples, and deflections. Model tests are described and the experimental results compared with the calculations. The good agreement confirms the analytical approach.

J. H. Baltrukonis, USA

Buckling Problems

(See also Rev. 1419)

1432. Kempner, J., and Patel, S. A., Creep buckling of columns, *NACA TN* 3138, 24 pp., Jan. 1954.

Formulas are presented for the determination of the creep deflection-time characteristics of an initially curved idealized H-section column. These results were obtained from closed-form solutions of the differential equation of bending (derived in *NACA TN* 3137) of a beam column whose creep properties are of a nonlinearly viscoelastic nature. The critical time (the time required for infinite deflections to develop) established by these solutions is tabulated and plotted for a wide range of the parameters involved.

From authors' summary by J. Heyman, England

1433. Ness, N., Time-dependent buckling of a uniformly heated column, *NACA TN* 3139, 18 pp., Jan. 1954.

Paper calculates the growth of deflection of an initially bent pin-ended Euler strut subject to constant end load and a steady increase of temperature with time. The material of the strut is assumed to obey an elasto-viscous law according to which the total strain is equal to the sum of an elastic term (Hooke's law) and a viscous term (Newton's law). Allowance is made for the variation of Young's modulus and the coefficient of viscosity with temperature. Two numerical examples are given, which illustrate the design problems arising in high-speed flight consequent upon aerodynamic heating and the loss of stiffness and creep which may accompany this. W. S. Hemp, England

1434. Chilver, A. H., The maximum strength of the thin-walled channel strut, *Civ. Engng. Lond.* **48,** 570, 1143–1146, Dec. 1953.

Short, thin-walled steel channel sections were tested as columns, failure occurring by local buckling. Some of the test specimens were ordinary channels; others were reinforced by lips at the outer edges of the flanges.

Author analyzes the relationship between average stress at failure (σ_{max}), compressive yield stress (σ_y), and local buckling stress calculated on the basis of elastic behavior (σ_{cr}). It is found that the test results follow the relationship $\sigma_{max}/\sigma_y = 0.736\,(\sigma_{cr}/\sigma_y)^{1/3}$.

Author also discusses results of similar tests on aluminum-alloy channel sections made by Heimerl [AMR **5**, Rev. 1676] and suggests that for aluminum-alloy members, the coefficient 0.736 in the above equation be replaced by the value 0.863.

J. W. Clark, USA

1435. Brown, E. H., and Hopkins, H. G., The initial buckling of a long and slightly bowed panel under combined shear and normal pressure, *Aero. Res. Counc. Lond. Rep. Mem.* 2766, 19 pp., June 1949, published 1953.

Elastic instability of long thin rectangular plates with slight longitudinal curvature under the combined action of uniform edge shear stresses and transverse normal pressures is considered analytically. This interaction problem is of importance in the design of wing panels subjected to aerodynamic suction forces. The theoretical analysis consists of a solution of the linearized shell stability differential equations subject to simply supported and clamped-edge conditions on the two long sides. Comparisons between the theoretical critical stresses and NACA test data show good agreement in all cases discussed. It is of interest to note that although the effect of edge fixity on critical shear stress is pronounced for flat plates, it becomes less important as the curvature and pressure increase. N. Grossman, USA

1436. Farrar, D. J., Investigation of skin buckling, *Aero. Res. Counc. Lond. Rep. Mem.* 2652, 62 pp., Oct. 1947, published 1953.

The present tests were conducted on aluminum-alloy plates in endwise compression, with varying conditions of edge support, to provide data on the buckling stress and postbuckling behavior of aircraft skins. All the plates tested were 35 in. long and nominally 0.064 in. thick. The plate width between the supports was varied between 35 and 120 times its thickness. Both clad (D.T.D. 546) and unclad (D.T.D. 646) material were tested. Three types of edge support were used: Rows of steel balls in vee-grooved blocks, intended to imitate pin-edge conditions; rows of steel rollers in recessed blocks, intended to imitate clamped-edge conditions; and a single type of stringer used in previous panel tests.

Measurements were made of the plate load and mean strain, and of the shape of the skin buckles. The test technique is discussed and the experimental results compared with theory. The ball-edge supports did not accurately represent pin-edged conditions, neither did the roller-edge supports accurately represent clamped-edged conditions. The tests provided some data on the effect of plasticity in seriously reducing the load carried by the plate after buckling and on the effect of cladding in reducing the buckling stress.

The buckling stresses measured for the panels with stringer-edge supports were in good agreement with theory. The load carried by the plate after buckling in this case was further reduced by the effect of plasticity in the stringers: a simplified theory is developed whose results are in agreement with the experimental observations.

The testing technique used is applicable to further investigations of the buckling of plates as part of a panel.

The information obtained on the effect of plasticity has an important bearing on the load-carrying capacity of panels, and while the present results may form the basis of design data sheets, it is desirable that the range of investigation be extended to cover other material specifications. From author's summary

Joints and Joining Methods

1437. Krefeld, W. J., and Anderson, G. B., Transition temperatures of structural steel beams with butt-welded splices, *Welding J.* **32,** 11, 538s–576s, Nov. 1953.

This investigation was primarily concerned with the resistance and transition temperatures of structural steel beams, composed of semikilled and fully killed steels and fabricated with butt-welded splices. Static and impact tests on 16-in. WF 71-lb beams, in addition to confirming the favorable effect of aluminum deoxidation in lowering the transition temperature of the as-rolled base metal indicated by Charpy tests, furnished information on the relative behavior of the two grades of steel with splices as-welded, welded, and "stress-relieved," and when welded with pre-

heat. The influence of these treatments was evaluated by increment drop impact tests on beams welded with E6011 and E6020 electrodes. Similar supplementary tests on beams composed of both steels, when welded with low-hydrogen electrodes as-welded and with preheat, furnish comparative data. Other data deal with the character of fracture and the effect of flame-cut holes in the beam web. The influence of a sharp notch at a critical location in an unwelded beam and the tendency of crack propagation are indicated by the results of supplementary tests.

From authors' summary by G. V. Smith, USA

1438. **Fisher, F. F., and Brown, G. J., Tube expanding and related subjects,** ASME Ann. Meet., New York, Dec. 1953, Pap. 53—A-174, 25 pp.

The paper summarizes experiences gained by the expanding of tubes into various types of powerhouse equipment and by the development of improved expanding tools and new rolling methods. Manual and controlled rolling methods are described and their relative merits discussed. Information is given relative to the making of rolled joints having optimum strength and stability.

From authors' summary

1439. **DeCecco, N. A., and Parks, J. M., The brazing of titanium,** *Welding J.* **32,** 11, 1071–1081, Nov. 1953.

Tests indicated that brazing with fine silver was successful when a suitable flux was used. Brazing with a material containing copper produced joints that failed by brittle shear. Phase diagrams (titanium-silver, titanium-copper, and titanium-aluminum) were prepared. Joints were made using oxyacetylene torch, furnace brazing in inert gas, resistance brazing, and recrystallization welding. The results obtained from using various fluxes are discussed, and test results are given. G. N. Cox, USA

1440. **Bennett, R. W., Welding for low-temperature service,** *Welding J.* **32,** 11, 1089–1097, Nov. 1953.

Author gives considerable information about the problem of forming suitable welds for pressure vessels for low-temperature service. Test results are given for welds made by a variety of methods and with various types of electrodes. Some discussion is given regarding the significance of the Charpy impact test for qualifying low-temperature welds. Author points out importance of grain structure in both plate and weld metal as regards impact toughness at lowered temperatures. W. J. Carter, USA

1441. **Calamari, P. L., Crum, F. J., and Place, G. W., An investigation on peening,** *Welding J.* **32,** 8, 387s–402s, Aug. 1953.

The effective use of peening to reduce residual welding stresses, to prevent cracking in highly restrained weldments, or to overcome distortion has long been a subject of controversial discussion among various authors and welding engineers. This present investigation, sponsored by the Welding Research Council and under the general guidance of a seven-member Peening Committee, has been carried out at the American Bureau of Shipping Laboratory in an attempt to evaluate the effects of some of the many variables of peening.

Whereas most of the previous peening investigations, such as carried out at the University of California and at the University of Washington in 1946, were concerned with the effect of peening on the residual stresses in weldments, this present investigation has been confined primarily to the effect of peening on some of the physical and metallurgical properties of worked metal. It is hoped that the results of this investigation will be useful in verifying or supplementing code requirements dealing with the optimum temperatures for peening, the restriction of peening to intermediate weld layers, or other controls on peening variables which can be adopted in practice. From authors' summary

1442. **Erdmann-Jesnitzer, F., and Kowalkowski, H., Influence of electrode covering on formation of specks in mild-steel weld metal and their origin** (in German), *Arch. Eisenhüttenw.* **24,** 7/8, 361–368, Aug. 1953.

Specks or "fish-eyes," i.e., small cavities surrounded by white areas of brittle fracture, are common phenomena observed in fracture surfaces in arc-welded mild-steel test specimens. The ability of the weld metal to undergo plastic deformation is greatly reduced by this mode of fracture, which is directly related to the amount of hydrogen dissolved in the metal.

The influence of various hydrogen-forming components in electrode coverings of the rutile type has been studied by the authors in a great number of weld tests based upon systematical variation of covering composition. Certain compositions are shown to produce weld metal fractures consistently free from fish-eyes.

The origin of this particular fracture mechanism is generally believed to be the diffusion of atomic hydrogen into small cavities in the metal, where the hydrogen changes into its molecular form, thereby producing internal pressures of more than 1000 atm. Added to an external load near the yield point, these pressures create three-dimensional states of stress leading to the formation of brittle cracks around the cavities.

A great amount of experimental evidence supporting this theory is reported by the authors, including experiments on electrolytical insertion of hydrogen into hydrogen-free welds, stress-relieving of porous welds by peening, radiographic examination of specimens during tensile testing, x-ray diffraction measurements on fracture surfaces, etc.

Authors' conclusions appear to be in close agreement with previous statements based upon research work carried out in the United States and elsewhere. H. Vinter, Denmark

1443. **Nippes, E. F., and Lesnewich, A., Effects of electrodes and heat treatments on mild steel weldments,** *Welding J.* **32,** 8, 353s–373s, Aug. 1953.

The ductility of weldments made with E6010 and E6016 electrodes on three plain-carbon silicon-killed 1-in. steels was studied with the Kinzel test. In the as-welded condition, the E6016 electrode was superior to the E6010 electrode only with the steel containing 0.25% carbon, the highest of the three carbon contents investigated. For all other conditions of preheat and postheat investigated in these three steels, there was no difference in the transition temperature between E6010 and E6016 electrodes. Although some improvement of the transition temperature of welded specimens was found with a 400 F preheat or a 24-hr postheat at 400 F, a combination of these two treatments was shown to be more effective. The most effective of the methods investigated for restoring the ducility of weldments was a 1-hr stress-relief heat-treatment at 1150 F. In summary, low-hydrogen electrodes, even with 400 F preheat and/or 400 F postheat, did not produce weldments in plain carbon steels which were as notch-tough as thermally stress-relieved weldments made with cellulose-type electrodes.

A preliminary study of the effects of the thermal cycles of welding on the ductility of three plain carbon steels was undertaken. Using a high-speed time-temperature control device, Schnadt-type samples were heat-treated to duplicate the heating and cooling cycles experienced at four positions near an actual weld. The results of slow-bend tests of the Schnadt-type samples with three conditions of stress concentration were presented and discussed. For

the plain carbon steels, the regions outside the normally considered heat-affected zone were shown to have poorest ducility, while the fine-grained regions were shown to have the best ductilities of the regions studied. From authors' summary

1444. Eickner H. W., The shear, fatigue, bend, impact, and long-time-load strength properties of structural metal-to-metal adhesives in bonds to 24S-T3 aluminum alloy, *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1836, 87 pp., June 1953.

Structural properties of nine commercially available adhesives were determined in accordance with Air Force Specification 14164. Included are effects of −70 F and 180 F temperature extremes, exposure to salt-water spray, and immersion in aircraft fluids. Information is timely and workmanship is thorough; materials tested, however, are identified only in code, which completely vitiates the report for the reader without a private key. This protects the manufacturers of inferior wares at the expense of the taxpayer and those who market quality products.

P. E. Sandorff, USA

Structures

(See also Revs. 1413, 1430, 1474, 1493, 1638, 1670, 1671)

1445. Kuhn, P., and Peterson, J. P., Stresses around rectangular cutouts in torsion boxes, *NACA TN* 3061, 71 pp., Dec. 1953.

Paper gives theory for effect upon stresses of a cutout in cover of uniform, stiffened box beam of doubly symmetrical rectangular cross section. Width of cutout is less than width of box. Structure is idealized to maximum simplification possible without losing problem. Bays without cutouts have four corner flanges. Bay with cutout has two additional stiffeners in top cover at edge of cutout and extending only over the length of the cutout bay. Stress modes arising from torsional loading consist of usual self-equilibrating four-flange mode and a second mode of four self-equilibrating axial forces in the top cover in the cutout bay.

When the beam is in pure torsion the top cover is a flat stiffened plate in pure shear. The stress distribution is computed from a set of empirical formulas involving a rate of decay determined from the theory of least work. With warping restraint, the four-flange mode is determined from the first author's well-known torsion-bending theory after replacing the cut panel by an equivalent solid panel. Additional stresses in cutout bay are then obtained from empirical formulas.

Theory and experiment show good agreement on two rectangular box beams in pure torsion since the empirical formulas were devised for this purpose. A small amount of data is given for a cantilever beam with a trapezoidal cross section. Authors use formulas for a rectangular cross section for this case and obtain fairly good agreement. Basic technique used by authors for treating cutouts seems very good for cases illustrated.

S. U. Benscoter, USA

1446. Heyman, J., The plastic design of grillages, *Engineering* **176,** 4587, 804–807, Dec. 1953.

The results of the beam tests, though showing some scatter, are statistically very good, the error in the mean value of the lower yield stress being only $\pm 1.8\%$.

Summarizing the results of the grillage tests, it may be said that they correspond well with the theory given in the paper. In all cases, the elastic deflections were in almost exact agreement with those given by the normal elastic calculations, and in no case did the deflections become unduly large until the predicted collapse load had been reached or exceeded. The simple plastic-hinge theory ignores the effect of strain-hardening, but, from the tests reported here, as for other types of plane structure, it appears that this theory will give a satisfactory design procedure. The use of the equation of virtual work enables trial designs to be checked very quickly and the correct collapse value determined. Other systems of loading, including combinations of distributed and concentrated loads, give simple terms in this equation and may be incorporated readily in the theory. From author's summary

1447. Markland, E., The calculation of elastic properties of non-prismatic structural members, *Civ. Engng. Lond.* **49,** 571, 63–64, Jan. 1954.

1448. Thrall, E. W., Jr., Fatigue life of thick-skinned tension joints, *Aero. Engng. Rev.* **12,** 11, 37–46, Nov. 1953.

Paper deals with test program instigated to determine ways of improving fatigue life of tension splices at starting point of a structural sweepback of aircraft wing. Tests are reported on 30 panels representing 12 different splice designs. Results are reported in the form of S-N diagram which should be useful for designing splices of type tested. Tests show that when splice is made in skin but not in stringer, early fatigue failure results. Results indicate that splice of skin and stringer can be made as safe from fatigue failure as basic sheet-stringer combination with no splices.

D. E. Hardenbergh, USA

1449. Moyse, J., Stirrup spacing in beams rapidly determined, *Civ. Engng., N. Y.* **23,** 10, 62–63, Oct. 1953.

1450. Rowe, R. S., Dimensionless curves aid design of flexible arch ribs, *Civ. Engng., N. Y.* **23,** 10, 63–64, Oct. 1953.

1451. Zanaboni, O., Analytic determination of joint displacements in pin-jointed trusses (in Italian), *G. Gen. civ.* 91, 8, 403–413, Aug. 1953.

Considering that joint displacements are vectors and that these can be expressed in complex form, author develops an analytic procedure to determine them. General formula obtained for a displacement gives the usual expressions of the components of every vector in the directions of the two Cartesian axes. Author says that both procedures, the usual one and the proposed complex form, demand the same amount of work for their application, but that he prefers the latter because it is more synthetic and evident. In reviewer's opinion, the calculation based on a system of Cartesian axes is not so mathematically synthetic but gives a clearer view of physical events.

Two illustrative examples are included.

A. J. Bignoli, Argentina

1452. Anonymous, New type of concrete pile. The Stent-Sykes pre-stressed hollow pile, *Dock. Harb. Author.* **34,** 399, 275–276, Jan. 1954.

In many situations and site conditions, hollow concrete piles possess a number of advantages, and a new type of concrete pile, prestressed and sectional, is developed.

The advantages are as follows: (1) Hollow piles can be made longer than solid piles of the same weight. As the section modulus is almost double that of a solid prestressed pile, less steel is required, and the greatly reduced tension (lifting and handling) permits a considerable increase in working load. (2) Hollow piles, being lighter for a given length, are easier to handle and cheaper to transport. (3) A sectional pile is flexible and economical, as standard units can be quickly assembled to any required length

and therefore large stocks of each length of pile are not required. If ground conditions are different from what were anticipated, it is very simple to make longer piles with the standard units. (4) No unit weighing more than 1/3 of a ton need be handled in the factory. As heavy equipment is not required, it is economic to manufacture units adjacent to the principal piling areas in any factory which is able to produce high-quality concrete. Thus long hauls can be avoided and transport costs reduced with a consequent widening of the area in which precast piles are economical. From summary

1453. **Scott-Wilson, W., Cantilever type reinforced concrete retaining wall,** *Civ. Engng. Lond.* **49,** 571, 47–48, Jan. 1954.

1454. **Lin, T. Y., and Scordelis, A. C., Selection and design of prestressed concrete beam sections,** *J. Amer. Concr. Inst.* **25,** 3, 209–224, Nov. 1953.

The basic concept of the action of an internal bending couple in a prestressed-concrete beam as compared to that in a conventional reinforced-concrete beam is introduced. Using this concept, criteria for the selection of shapes and formulas for the design of sections are developed. Tables giving design constants are listed for various common beam sections. Relative advantages and disadvantages of different types of cross sections are discussed. Using the method developed, an example beam section is designed. From authors' summary

1455. **Fritz, B., Compensation of the friction loss during prestressing** (in German), *Beton. Stahlbeton.* **48,** 10, 225–229, Oct. 1953.

For post-tensioned curved prestressed-concrete members, expressions are developed, considering friction loss, for stress and stretch for the four cases: (1) Prestressing from one end; (2) equal prestressing from both ends at the same time; (3) prestressing from first one end and then the other end; (4) prestressing from one end with partial prestressing from the other end. Circular concrete container is analyzed as numerical example. Expressions similar to those for the curved member are developed for the straight member with prestressing unit curved. Reviewer believes expressions are useful, providing coefficient of friction can be predetermined. R. B. B. Moorman, USA

1456. **Gifford, F. W., Tests on end-anchored unbonded prestressed concrete beams having parabolic steel eccentricity, subject to uniformly distributed loading,** *Mag. Concr. Res.* no. 13, 27–36, Aug. 1953.

Paper describes tests carried out on a series of very small prestressed concrete beams. Reinforcement was end-anchored (no grouting). Beams varied with width from 2 1/4-in. to 3-in. by 1/4-in. increments. All beams were 5 in. deep. From author's summary by A. H. Finlay, Canada

1457. **Sherman, J., Analysis of continuous composite steel and concrete beams,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 251, 21 pp., Aug. 1953.

Paper is concerned with concrete-slab and steel-beam highway bridges in which composite action is achieved by shear connectors welded to top flange of steel beams. Two- and three-span continuous beams are analyzed, based on assumption that, since concrete does not take tension, moment of inertia of full composite section is effective only in regions of positive bending moment, i.e., where concrete slab is in compression. Stresses computed by this method are compared with stresses based on commonly used assumption that moment of inertia of composite beam is uniform. Stresses computed by author's method are significantly higher at section of maximum positive moment and lower at maximum negative moment than stresses computed by alternate method if the ratio of moment of inertia of composite beam to that of steel beam alone exceeds 1.5. Author also shows that maximum deflection in three-span continuous beam with single concentrated load may be 40% larger than value computed on assumption of uniform section. Solution of cubic and quartic equations which arise is accomplished neatly by use of Horner's method. W. E. Black, USA

1458. **Milbradt, K. P., and Kofodimos, T. J., Design of monolithic concrete frame—prestressed,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 217, 65 pp., July 1953.

1459. **Lin, T. Y., Allowable stresses and load factors for prestressed concrete,** Proc. Western Conf. Prestressed Concrete, Univ. of Calif., Los Angeles, Nov. 1952; 143–156, Jan. 1953.

First, a comparison is given of prestressed concrete and reinforced concrete, emphasizing basic differences. This is followed by discussion of general bases for choice of allowable stresses and specific factors which lead to variability of these allowables in prestressed concrete. Values of allowable stress in use in Europe and in the United States are tabulated for comparison and the similarities and differences are discussed. Author considers each type of stress, giving reasons why specific numerical values are recommended for design. Load factors (i.e., multiples of service load which members should sustain at first cracking or at failure) are discussed and specific numerical values of load factors are suggested. In total, paper is an excellent survey of the most important factors which must be considered in any attempt to specify allowable stresses and load factors for prestressed concrete. M. J. Holley, Jr., USA

1460. **Iwasyk, S., Transportable silos on the building sites** (in Polish), *Inżyn. Budown.* **10,** 1, 8–10, Jan. 1953.

In the building industry, construction work in winter depends on the solution of some specific problems for the influence of low temperatures; e.g., the use of nonfrozen aggregate for concrete. Hitherto, and this under favorable circumstances only, frozen aggregate has been warmed up by means of hot water or steam used before or during the mixing, etc. This method, however, is insecure and unhandy and results in a slow rate of construction, warming up of the aggregate being rather a slow and laborious operation. Therefore, engineers engaged in planning winter work would like to have nonfrozen gravel stored. Space for laying gravel in prisms often being limited at the site, the author elaborates the idea of storing gravel in silos.

Sites are transitory, so silos for gravel have to be transportable—hence author's idea of silos out of precast elements. He connects adequately chosen elements by means of anchors and wedges into a whole. In his computations he uses the well-known Jansen's exponential function. An opening valve, allowing transfer of gravel on cars, is provided in the bottom of the silo. The walls of the silo are frosted-insulated. One silo of the Iwasyk type can store up to 200 m of gravel, sufficient for a smaller site. A steady supply of nonfrozen aggregate necessary in winter can be secured by having some silos of this type successively filled up and emptied at the site. Cz. Klos, Poland

1461. **Siess, C. P., and Viest, I. M., Studies of slab and beam highway bridges, Part V. Tests of continuous right I-beam bridges,** *Univ. Ill. Engng. Exp. Sta. Bull.* no. 416, 91 pp., 1953.

This continuation of a large project involves laboratory tests

on three models of two-span bridges, each consisting of five steel beams supporting a reinforced-concrete slab. In two bridges, the slab was tied to the beams with shear connectors; in the third, no connection was provided. The spans were each 15 ft long and the beams were spaced 1.5 ft apart.

About 325 SR-4 strain gages were used to determine (1) influence lines for positive and negative moments, (2) location of loads to produce maximum moments, (3) distribution and magnitude of strains in slab and beams, and (4) load at first yielding in tests to destruction. Deflections, loads at failure, and the manner of failure were also determined. The test results show good agreement with theoretical results.

The test results on this and three other University of Illinois Bulletins are used to support general conclusions regarding (1) moments in individual beams, (2) stresses in slab reinforcement, and (3) composite action. Marshall Holt, USA

1462. Quade, M. N., Special design features of the Yorktown bridge, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 168, 15 pp., Jan. 1953.

Paper deals with description of a new movable bridge the superstructure of which contains a unique arrangement of two swing spans placed in tandem each of 500 ft in order to provide a 450-ft clear shipping channel.

Each span is longer than any previous swing span built. Substructures also would by themselves make this bridge remarkable.

Water depth at the seat of the six river piers varies from 50 to 80 ft. River bed is 10 to 40 ft soft mud underlaid by sand or silt strata in which most of piers are actually founded. But the principal material supporting piers is a medium-to-stiff clay underlying sand. The net unit bearing from vertical loads was limited to 2 tons per sq ft in excess of that resulting from the weight of the existing overburden at the depth of the bottom of the pier base. Two piers were sunk 150 ft below main tide level. Small and uniform settlements may occur during the first 50 years of the life of the bridge and will create no serious structural maintenance problems in the opinion of the designers. Provisions are taken to make easy the eventual jacking up of the superstructure. 110-ft-high all-welded steel caissons, towed 60 miles, were used; dredging wells are of 12 ft diam. Design of caisson is described.

The structural behavior of this double swing under live load is somewhat complicated by the fact that shore ends of the swing spans rest on elastic supports (the cantilever ends of the fixed truss spans). This feature makes it impossible to equip the bridge with wedge end lifts to insure positive dead-load and live-load reactions at the ends of the span, as is usual in swing bridges. It has been necessary, therefore, to use bascule-type shear locks to provide live-load support for the ends of the swing spans. In total, three pairs of lock bars are installed which transfer live-load shear from one part of the bridge to another. Detail of lock bars, floor joints stops, operation are given.

Reviewer considers it unnecessary to point out the ingenuity and capacity shown by designers in fulfilling their task. However, in view of the involved design adopted, full information about the justification of the same in comparison with other solutions would have been welcome. H. O. Albano, Argentina

1463. Basu, F., A simplified method of design of symmetrical rigid frame bridges of single span, *J. Instn. Engrs., India* **33,** 4, 385–398, June 1953.

Paper describes method for expediting design of two-hinged rigid frame bridges by use of approximate influence line diagrams. By making several simplifying assumptions, e.g., that the moment of inertia varies lineally from knee to crown and from knee to base, etc., author is able to construct bending-moment influence diagrams for various rise-span ratios and various ratios involving the stiffnesses of beam and leg. Sufficient accuracy is claimed for use in preliminary design calculations. Reviewer believes that considerable saving in time may be effected by use of method. W. E. Black, USA

1464. Turnbull, W. J., and Mansur, C. I., Relief well systems for dams and levees, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 192, 20 pp., May 1953.

Extensive experiments were made, with large models, on the effect of relief well systems on a landward side of dams and levees, with resulting clarification of principles of their construction. The experiments were concerned with different cases and combinations for various kinds of top strata, with underlying homogeneous and stratified pervious strata, and with vertical, horizontal, or combined seepage entrances. Model-test results obtained are given with diagrams and discussed concisely. Many useful data concerning designs and engineering practice are also included. D. Krsmanović, Yugoslavia

1465. Hořejší, J., Influence of continuous loading on downstream fall of gravity dams (in Czech), Anniv. Vol. Zdeněk Bažant, Praha, Technic.-Vědec. Vydavat., 85–118, 1952.

Author extended Prof. Bažant's solution ["Contribution to the theory of masonry dams," Praha, 1915], introducing uniform vertical as well as horizontal loading on the downstream face of a dam. General expressions for normal and tangential stresses in vertical and horizontal sections are given and principal stresses are introduced. Solution is given for a symmetrical as well as a general form of a dam. Author simplified task by supposing linear distribution of vertical normal stresses along horizontal section. As fill is often used on downstream face of dams, solution has considerable practical importance. Comparison of author's deduction with a theoretically exact one or with measurements is desirable. V. Mencl, Czechoslovakia

1466. Mansfield, E. H., The effect of spanwise rib-boom stiffness on the stress distribution near a wing cut-out, *Aero. Res. Counc. Lond. Rep. Mem.* **2663,** 21 pp., Dec. 1947, published 1952.

1467. Carey, W. N., Jr., Special instruments measure WASHO road-test data, *Civ. Engng., N. Y.* **23,** 10, 45–47, Oct. 1953.

1468. McNown, J. S., Hydrodynamic earthquake forces on submerged structures, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 233–242, 1953.

For geometrically simple structures, the potential-flow theory is useful in estimating hydrodynamic earthquake forces. The usual causes of inaccuracies in such calculations—viscosity and separation—are ineffective in these motions because (a) the flow persists for only a short time, (b) the maximum velocity is correspondingly small, and (c) the significant pressures are related to the acceleration. Only in the definition of the boundary conditions, such as the shape of the structure and of the reservoir, are errors introduced which approach in significance those arising in the prediction of earthquake intensities. From author's summary

1469. Wiens, G., High-speed trains. Suggestions and completed projects (in German), *ZVDI* **95,** 36, 1197–1207, Dec. 1953.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1432, 1433, 1446, 1482)

1470. Lee, E. H., Plastic flow in a rectangularly notched bar subjected to tension, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-29, 7 pp.

A two-dimensional bar with a rectangular notch on each side (symmetrical) is analyzed. Plastic strains are assumed large so that the elastic strains are negligible. Yielding is assumed to occur according to the Saint Venant-von Mises theory (or constant octahedral shearing stress) which for plane strain gives the same results as the Tresca theory except for a numerical factor. Both the geometry of the yield condition (constant maximum shearing stress), the motion and the forces required to maintain it are determined. It is found that the velocity pattern may undergo either one or two changes or may remain unchanged up to final separation, depending on the geometry of the notch and bar.

This is a very interesting paper and certainly a significant one since it presents the first solution of unsteady plane plastic flow with deforming free boundaries. M. P. White, USA

1471. Hershey, A. V., The plasticity of an isotropic aggregate of anisotropic face-centered cubic crystals, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-63, 9 pp.

The plasticity of a polycrystalline aggregate is expressed in terms of the plasticity of the individual grains. A self-consistent method is used in which a typical grain is regarded as a spherical crystal embedded in an isotropic medium. It is assumed that the local deviation of stress from the average stress is proportional to the local deviation of strain from the average strain, and that plastic flow begins when there is an average of three active systems per grain. Results are obtained, in the special case of elastically isotropic face-centered cubic metals, for the yield surface, plastic potential, formation of preferred orientations, and residual stresses. The standard of obscurity customary in papers on this subject is fully maintained. It is not clear whether the author regards the present method as an improvement on that of Bishop and Hill [AMR **5**, Rev. 104; also, *Phil. Mag.* (7) **42**, p. 1298, Nov. 1951].

F. R. N. Nabarro, South Africa

1472. Hwang, C., Plastic collapse of thin rings, *J. aero. Sci.* 20, 12, 819–826, 845, Dec. 1953.

Limit analysis is applied to elliptic rings under concentrated loads that are parallel to the major axis and symmetrically arranged with respect to it. A formula for the load-carrying capacity is derived which includes the circular ring as a special case. A chart for the location of the yield hinges is given and the elastic-plastic deformation at impending collapse is determined.

W. Prager, USA

1473. Olds, G. C. E., Creep curve for a precipitation-hardened alloy, *Nature* **172,** 4387, p. 999, Nov. 1953.

1474. Brady, W. G., and Drucker, D. C., An experimental investigation and limit analysis of net area in tension, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 296, 35 pp., Oct. 1953.

Paper is concerned with weakening effect of holes in tension members. Upper and lower bounds are determined for the limit load required to produce unrestricted flow across the entire member. These bounds, obtained by considering kinematic velocity fields and static stress fields, respectively, confine the limit load within a reasonably narrow range, enabling the results to be checked experimentally. Investigation included six configurations of staggered rows of holes, and tests were carried out both on hot-rolled steel and aluminum-alloy sheet. Despite variations of material properties, the results agree remarkably well with theory and favor slightly the maximum shear-stress theory of breakdown, although a compromise between this criterion and the von Mises criterion gives better correlation. The $s^2/4g$ rule for riveted tension joints is shown to be a reasonable approximation, although it may be unsafe for a single sheet tested in tension.

J. Heyman, England

1475. Kennedy, A. J., A single crystal extensometer, *Rev. sci. Instrum.* **24,** 7, 505–512, July 1953.

The device described consists of a mechanical network which, when loaded, extends a crystal specimen with a constant resolved shear stress on the glide planes in the glide direction. Usual methods which compensate the load for rotation of the glide planes with respect to the crystal axis result in inhomogeneous rotation due to the restraints of the end grips. The system described eliminates this difficulty by rotation of the end grips as deformation proceeds. The device consists of a parallelogram with two opposite sides free to slide on rollers while maintaining constant angles between the sides. The load is applied parallel to the direction of motion of the sides and the crystal is extended on the parallelogram diagonal. The device can be preset for any initial crystal orientation.

For x-ray study or microphotography it is desirable that the crystal be extended along the line of the original specimen axis with the midpoint fixed with respect to an external frame of reference. This can be accomplished by constraining the system with a second parallelogram rotated 180° and affixed to the first.

S. P. Jones, Jr., USA

1476. Bergen, J. T., and Patterson, W., Jr., Anomalous viscous flow at very low rate of shear and small shearing stress, *J. appl. Phys.* **24,** 6, 712–719, June 1953.

Authors point out unfilled need for viscosity measurements at very low shear stresses. They designed a translated coaxial cylinder viscometer of the Pocchetino type for measurements down to shear stresses of 0.01 dynes/cm² and shear rates of 0.001 sec^{-1}. Theory of instrument with Newtonian fluids is reviewed; calibration with NBS oils shows end effects necessitate a 35% correction. Data are shown for GR-S latex, gum tragacanth suspension, and a rubber suspension. Data on household paints and organosol coatings show yield values of 0 to 7 dynes/cm²; these correlate well with leveling and sag behavior of paints. Conventional extrapolation methods for finding yield value give much higher results. I. M. Krieger, USA

1477. Sachs, G., Brown, W. F., Jr., and Newman, D. P., The effect of stress concentration on the creep strength of materials (in German), *Z. Metallk.* **44,** 6, 233–239, June 1953.

Creep tests with smooth cylindrical test pieces do not provide data to be used with confidence for components incorporating stress concentrations. Article is review of 20 papers investigating creep notch sensitivity of different ferrous alloys. Situation is extremely complex. Notch sensitivity depends on chemical composition, heat-treatment, testing temperature, time to rupture, notch depth, and notch sharpness. Low values for deformation of notched test pieces occur together with high notch sensitivity. This is consequence of stress concentrations which seem to be maintained at original magnitude during test. Form of notch has same effect on creep notch sensitivity as in ordinary tensile test.

R. Week, England

1478. Oldroyd, J. G., The elastic and viscous properties of emulsions and suspensions, *Proc. roy. Soc. Lond.* (*A*) **218,** 1132, 122–132, June 1953.

Steady flow viscosity of a dilute emulsion was previously derived by Taylor [*Proc. roy. Soc. Lond.* (*A*) **138,** 41, 1932]. Supplementing this work, author allows the rate of shear and the shearing stress to vary in time, thus introducing a retardation and a relaxation time as rheological properties of the emulsion. Time effects are brought about by the interfacial tension opposing the straining of the droplets. Emulsions behave somewhat like suspensions of elastic solid particles as investigated by Fröhlich and Sack [*Proc. roy. Soc. Lond.* (*A*) **185,** 415, 1946]. The mathematical methods of these authors are readily adapted to the present problem. As a result, the two-time constants are obtained in terms of the viscosities of the two liquids and the interfacial tension and are found to be proportional to the radius of the droplets. The previous expression for steady-flow viscosity is confirmed. A third component of an emulsion or suspension which forms a film between the substances (stabilizer) may cause in effect a slippage at the surface of the drops or particles. Author derives the effect of the slipping on the three rheological constants. R. Eisenschitz, England

1479. Bhagavantam, S., Photo-elastic behavior of cubic crystals. New methods of distinguishing between different classes, *Proc. Indian Acad. Sci.* (*A*) **37,** 5, 585–588, May 1953.

The photoelastic behavior of chosen prisms belonging to different classes of the cubic system of crystals is studied in detail for various orientations. It is shown that five out of the eighteen orientations studied furnish a simple experimental test for distinguishing the T and T_h classes from the T_d, O, and O_h classes. In the former, because of the fact that $q_{12} \neq q_{13}$, there is an angular displacement of the principal axes of certain sections of the optical ellipsoid, caused by the application of linear compressional stresses, and such an effect may easily be observed and measured. It has also been shown that there is one special orientation for which all the five classes of cubic crystals should exhibit such an effect because $q_{11} - q_{12} \neq q_{44}$. This vanishes for isotropic substances, as should be expected. From author's summary

1480. Bhagavantam, S., and Krishna Rao, K. V., Photo-elastic behavior of cubic crystals. Displacement of principal axes caused by linear stresses, *Proc. Indian Acad. Sci.* (*A*) **37,** 5, 589–591, May 1953.

The paper furnishes measurements in respect to the tilts observed of the principal axes in sections of the optical ellipsoid caused by linear stresses applied to prisms cut out of different cubic classes of crystals. In most cases, such effects are characteristic only of the T and T_h classes and are absent in the T_d, O, and O_h classes. They serve, therefore, to distinguish between the two types. There is a fair agreement between the measured and calculated values in practically all the cases studied.

From authors' summary

1481. Hollomon, J. H., and Turnbull, D., Nucleation, *Progress in Metal Physics* **4,** pp. 333–388, 1953; New York, Interscience Publishers.

This review article on the nucleation of heterogeneous phase transformations critically discusses the theories and experimental results for the size and the growth rate of nuclei of a new phase, the influence of overheating, supercooling, compression, strain, and structure. The following transitions are treated in detail: Condensation and evaporation, crystallization from liquids, and solid-solid transformations with special attention to the transformation of the martensite type. L. Meyer, USA

Failure, Mechanics of Solid State

(See Revs. 1472, 1488)

Material Test Techniques

(See also Revs. 1400, 1499, 1502)

1482. Umstätter, H., and Schwaben, R., Introduction to viscosity and rheometry [Einführung in die Viskosimetrie und Rheometrie], Berlin, Springer-Verlag, 1952, xii + 152 pp. DM 16.50.

This book deals primarily with the theory and practice of viscosity measurement as applied to liquids exhibiting Newtonian viscosity. The discussion of apparatus and procedures for measuring non-Newtonian viscosity, viscoelasticity, and plasticity is quite limited and incidental.

Book is divided into three parts: Part I, Viscosity as a material constant; part II, Mathematical foundations of viscometry; and part III, The absolute viscometers. Part I is based on Maxwell's relaxation theory and gives the mathematical developments that lead to Newtonian viscosity, stress relaxation, viscous shear waves, and viscoelastic effects in periodic deformations. The treatment throughout is limited to a single relaxation time and, hence, is inadequate for interpreting most of the recent work on periodic deformations of viscoelastic materials. Some additional subjects treated in part I have no apparent relevance to the main subject of the book and are not referred to again. They are subjects to which very little attention has been given in the rheological literature.

Part II gives an excellent and fairly complete summary of the mathematical analyses of Newtonian viscous flow under the boundary conditions that have been successfully treated by the methods of classical hydrodynamics. The viscometers treated include all the usual types, capillary, rotational, falling ball, and compressional; and all the established correction terms are included which take account, to the first approximation, of edge, wall, and inertia effects.

Part III gives brief description, with figures in most cases, of one band viscometer, 23 capillary viscometers, nine falling viscometers including the Williams compression plastometer, 17 rotation viscometers, and five oscillation viscometers. In discussing so many instruments the space given to any one must necessarily be limited, and a few of them are given only a few lines. The purpose of many of the designs is given, but there is little attempt to judge their effectiveness or relative advantages and disadvantages. However, if a rheologist has any particular experimental problem in the viscosity measurement of a Newtonian fluid, he will probably find a suitable viscometer described in part III.

Following part III there is a lengthy appendix containing a valuable discussion of a number of topics related to viscometry. Among these topics are sources of error, thermostats, and special chronometers.

There is a 3-page subject index. The 6-page author index has an annoying defect in that page references are not given.

In the reviewer's opinion, part II of this book is good; part III also is good as far as it goes, but it gives inadequate coverage of apparatus and associated rheometry theory applicable to non-Newtonian liquids and to viscoelastic and viscoplastic materials. In making the suggestion that part III be thus expanded if another edition is published, it must at the same time be admitted that such an expansion would possibly require some additional associate authors. Modern rheometry has become so diversified and so complex in its theory that no single author (or

two) can be expected to be competent to present the whole field with authority.

One section of part I (pp. 9 and 10) is, in reviewer's judgment, basically wrong. The errors develop from some bad elementary calculus and also, apparently, from a puristic insistence that, since the negative exponential function can never in finite time decay to zero, a truly steady state can never be attained in experiment. This view concerning the attainment of a steady state is not stated explicitly, but it seems to be the only basis on which some of the authors' conclusions can be understood; the basis being, namely, that the conclusions are valid and important during an initial stage before the attainment of a steady state. An example of bad calculus is the following. By ignoring the possibility that a constant of integration, C_1 in eq. (14), can be zero, the unjustified conclusion is drawn: "Every liquid flowing with constant velocity must therefore be a so-called Bingham liquid."

Two errors of substituted figures may be mentioned. Fig. 76, over the title "Williams Parallel Plate Plastometer," bears only a resemblance in principle to the much simpler instrument actually described by Williams. The figure used by Umstätter and Schwaben seems to have been taken, without credit, from an article by G. J. Dienes and H. F. Klemm [*J. appl. Phys.* **17,** p. 458, 1946]. Again, the apparatus shown in fig. 91, labeled "Ewart and Mooney Viscometer," resembles only slightly the conicylindrical design as used by Mooney and Ewart. The true origin of fig. 91, like fig. 76, is not given. The data quoted concerning precision and operating range presumably apply to the instrument shown. They do not apply to the Mooney-Ewart instrument.

This unpretentious little book has faults, but it will prove valuable for its principal function as a reference work on the classical theory and methods of viscometry.

M. Mooney, USA

1483. Witt, R. K., Hoppmann, W. H., II, and Buxbaum, R. S., Determination of elastic constants of orthotropic materials with special reference to laminates, *ASTM Bull.* no. 194, 53–57, Dec. 1953.

Authors utilize a simple and ingenious testing method to determine the modulus of elasticity, modulus of rigidity, and Poisson's ratio of several fiber-resin laminates having marked directional or orthotropic properties. They first develop some of the theory of orthotropic materials by means of reference to the pertinent literature and then develop the theory of this igenious device. Its applicability is checked against materials of known elastic constants. The method shows considerable promise of providing a means of obtaining the elastic constants of this new and rapidly developing field of materials. A. G. H. Dietz, USA

1484. Fenner, A. J., and Willoughby, G., Creep test in inert atmospheres, *J. sci. Instrum.* **30,** 11, 406–407, Nov. 1953.

1485. Mason, P., A compression testing instrument for use with pastes, *J. sci. Instrum.* **30,** 11, 418–421, Nov. 1953.

An instrument of low frictional resistance is described in which small cylindrical specimens can be compressed by loads up to several kilograms. Loads can be applied at different constant rates or in separate increments and the deformations can be observed, using either a dial gage or an optical lever. Observation of the rate of compression of a bitumen at constant load gives a value for the viscosity substantially in agreement with that found by a concentric cylinder method. The usual method of testing pastes is at a constant rate of loading, a record of specimen height and load being obtained by taking a cinefilm of the dial gage and a stop watch by its side. Typical test results for pastes are discussed, concerning the effects of roughness of compression surfaces, of addition of filler to a paste, and of variations in the rate of loading. From author's summary

Mechanical Properties of Specific Materials

(See also Revs. 1439, 1440, 1442, 1444, 1479, 1480)

1486. Smithells, C. J., Tungsten—its metallurgy, properties, and applications, New York, Chemical Publ. Co., Inc., 1953, xii + 326 pp. $8.50.

Book gives a comprehensive treatment of the metallurgy, chemical and physical properties, and industrial applications of tungsten. As an introduction, author outlines mineralogy of tungsten ores and follows this with a step-by-step treatment of primary and secondary raw materials for production of metallic tungsten. Succeeding chapters deal with manufacture of ductile tungsten, metallography, effect of cold work and annealing on physical properties, the properties as a function of temperature, thermionic properties, tungsten-iron alloys and tungsten steels, nonferrous alloys, and industrial applications of tungsten and tungsten carbides and hard tungsten alloys. The final chapter covers chemical and spectrographic methods for the determination of impurities. In this revised edition the author has again enlisted the help of several experts for writing the chapters on special phases of the subject. The book, which contains 225 illustrations and numerous tables which present helpful data concisely, should serve as a valuable reference volume on the subject.

G. M. Sinclair, USA

1487. Hershey, A. V., The elasticity of an isotropic aggregate of anisotropic cubic crystals, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-62, 5 pp.

Author discusses the calculation of the elastic moduli of a polycrystalline aggregate in terms of the elastic properties of the individual grains, assuming that the polycrystalline metal has cubic structure and that the grains are isometric and randomly oriented. The problem resolves itself into two parts—the calculation of the stress and of the strain within each grain; the former is found by analyzing the stress distribution in the neighborhood of a spherical cavity is an isotropic medium, and the latter is expressed in terms of the average stress in the polycrystal by parameters which are related to the actual elastic constants.

There is an excellent collection of experimental data on the elastic constants of polycrystalline cubic metals; while the data confirm the order of magnitude of the theoretical results, the author concludes that further experimental work is required to provide a quantitative test of the theory.

R. M. Davies, Wales

1488. Akimov, G. V., and Romanov, V. V., Effect of temperature on the rate of corrosion on aluminum and some aluminum alloys (in Russian), *Dokladi Akad. Nauk. SSSR (N.S.)* **91,** 2, 281–283, 1953.

Samples of commercially pure aluminum, duralumin, and magnalium were corrosion-tested in 1N chloride solutions with pH values of 1, 3, 6, 11, and 13 at temperatures of 0, 20, 50, and 80 C. The resulting weight changes are shown graphically as a function of temperature for the various solutions. Resulting surface conditions of the test samples are described.

Anna M. Turkalo, USA

1489. Nonveiler, F., Lahodny, A., and Tezak, S., Gas in aluminum alloys (in Croatian), *Tehn. Pregled* **5,** 2, 51–56, 1953.

The source of gases in solid and molten aluminum and their

influence on the quality of the final product are briefly discussed. Then some methods for semiquantitative control of gas content in molten aluminum are described and a simple but satisfactory laboratory control equipment is given. The second half of the paper describes a degassing chemical agent ILAM VI b_6(25.0% C_2Cl_6; 36.5% NaCl; 28.5% KCl; 5% NaF; 5% Na_3AlF_6) and its influence on the porousness of aluminum alloys. The minimum quantity of the degassing agent was 0.25% of the weight of the charge, but for practical purposes a minimum of 0.5% is required. The escaping of gases from the molten metal is slow immediately after the chemical reaction has taken place, reaches its peak after six minutes, and is practically finished in 25 minutes.

A. Kuhelj, Yugoslavia

✎1490. **Kühnel, R., Slide bearing materials. 2nd ed. [Werkstoffe für Gleitlager]**, Berlin, Springer-Verlag, 1952, 454 pp. DM 69.

This very interesting book contains many results of German World War II experience in bearing construction, when metal shortages necessitated much new design. Some 323 figures and photos and a great number of tables testify to the completeness of this book. An introductory section discusses testing and evaluation methods for bearing materials.

The second and major section covers metallic bearing materials in pure and alloy form, with a number of contributers discussing materials in which lead, zinc, cadmium, aluminum, magnesium, silver, or copper is the main component. Each treatment details the development, physical and chemical properties, metallurgical characteristics, and operating behavior of the material.

The third and, to the reviewer, most interesting section is devoted to nonmetallic materials—wood, artificially created substances, and pressed coal. The reviewer is not aware of as complete a discussion of these materials in English; many technical details—fabrication, applications, operating characteristics, test results, and optimum utilization—are covered.

This book is very highly recommended. It is an attractive, well-printed volume, striking a good balance between extensive subject coverage and sufficient detail to enable one to make preliminary design decisions. B. W. Augenstein, USA

1491. Bergstrom, S. G., Curing temperature, age, and strength of concrete (in Swedish), *Swedish Cem. Concr. Res. Inst. Bull.* no. 27, 15 pp., 1953.

The effects of curing temperature and age on the strength of concrete can be expressed in terms of a single parameter given by the product of age and temperature, as has been suggested by A. G. A. Saul in *Mag. Concr. Res.* no. 6, p. 127, 1951. In this parameter, the temperature is reckoned from −10 C, which seems to be a reasonable value of the lowest temperature at which any appreciable increase in strength can take place. In the present paper, the correctness of this assumption is verified by means of check calculations made on previously known test series and on some new Swedish tests. It is to be noted, however, that special precautions must be taken to protect the concrete from freezing during the initial period after placement, and that the humidity of the ambient air must be taken into account. Moreover, the deterioration of concrete subjected to repeated freezing and thawing must be studied as a separate problem.

From author's summary by C. J. Bernhardt, Norway

1492. Macfarlane, C. J., The effect of detergents on concrete strength, *Civ. Engng. Lond.* **49,** 571, 59–61, Jan. 1954.

1493. Anonymous, Laboratory investigation of certain limestone aggregates for concrete, *Wuys. Exp. Sta. tech. Memo.* no. 6–371, 87 pp., Oct. 1953.

1494. Stone, R. L., Temperature gradient method for determining firing range of ceramics bodies, *J. Amer. ceram. Soc.* **36,** 4, 140–142, April 1953.

1495. Brown, P. D., and Robertshaw, J., The in-situ measurement of Young's modulus for rock by a dynamic method, *Géotechnique, Lond.* **3,** 7, 283–286, Sept. 1953.

Article describes a simple method of determining Young's modulus of rock foundations in situ. The method relies upon the close correlation which is shown to exist between Young's modulus and the longitudinal wave velocity in a rock, and involves only the measurement of the longitudinal wave velocity. A method of measuring the longitudinal wave velocity in a rock is described, with particular reference to measurements recently made on a dam site in Iraq. From authors' summary

1496. Willis, A. H., Stressed rubber, *Trans. Inst. mar. Engrs.* **65,** 10, 253–258, Oct. 1953.

1497. Stuart, D. A., and Anderson, O. L., Dependence of ultimate strength of glass under constant load on temperature, ambient atmosphere, and time, *J. Amer. ceram. Soc.* **36,** 12, 416–424, Dec. 1953.

Static fatigue is one of the important unsolved problems in the fracture of glass. Many explanations have been offered, a few of which are mentioned by the authors. The present theory is in the group stemming from reaction-rate theory. The authors set up a model in terms of the breaking and forming of bonds in an elastic network in a way that allows them to calculate the net rate at which bonds break when the specimen is stressed, presumably in tension, and to set up a criterion for fracture. This model admits of a stress below which no fracture takes place in a finite time. Good agreement is obtained with the existing experimental data, but such is its nature that most of the other theories also check these data about as well. Reviewer has also developed a theory based on reaction-rate theory [see *J. chem. Phys.*, Oct. 1947]. E. Saibel, USA

1498. Anonymous, Glass as construction material (in German), *Technik* **8,** 10, 675–680, Oct. 1953.

1499. Greenfeld, S. H., Effects of thermal shock on the durability of asphalt coatings under accelerated test, *ASTM Bull.* no. 193, 46–50, Oct. 1953.

1500. King, R. F., and Tabor, D., The effect of temperature on the mechanical properties and the friction of plastics, *Proc. phys. Soc. Lond. (B)* **66,** 405, part 9, 728–736, Sept. 1953.

Relation between coefficient of friction μ and ratio of shear strength S to indentation hardness P is shown as a function of temperature for four plastics. Agreement with the adhesion theory (μ equals S/P) was found for polyethylene. With other materials, μ varies with S/P, but not equally. Authors suggest that deviation from theory toward lower μ for polytetrafluoroethylene was due to low adhesion between molecular chains; toward higher μ for polytrifluorochloroethylene and methacrylate was due to a hydrostatic state of stress superimposed on the shear stress at the junctions of contact.

W. N. Findley, USA

1501. Jorczak, J. S., Mechanical properties of polysulfide polymers, ASME Ann. Meet., New York, Dec. 1953. Pap. 53–A-170, 9 pp.

1502. **Minami, Y., Compressive creep tests on wood,** *Bull. Fac. Engng., Yokohama Nat. Univ.* **2,** 23–46, Mar. 1953.

In continuation of the author's studies of flexural and tensile creep of wood, he investigated static compressive creep of two woods (Hinoki and Sugi) parallel to grain and in radial and tangential directions to annual rings with 10 × 10 × 20-mm specimens. The 20-mm length was in the direction of load application. Strain recordings for repetitive and successively increased load applications and load releases resulted in observations of the hysteresis at various load stages. Complete test data are presented.

Among the findings the rate of creep in compression was larger than that in tension. The respective creep limits, on the basis of two definitions, were found to be between 18–30 and 46–57% of the compressive strengths of the two woods at their moisture contents during testing. E. G. Stern, USA

1503. **Kollmann, F., The future tasks of research in wood technology,** *Inter. Holzmarkt* no. 24, 15–18, Dec. 1953.

During the opening ceremonies of the Austrian Wood Research Institute in Vienna in October 1953, many excellent pointers for future research in the field of wood technology were presented by Dr. Kollmann when reviewing the present status of available information. E. G. Stern, USA

1504. **Morris, G. J., Thermal properties of textile materials,** *J. Text. Inst. Trans.* **44,** 10, T449–T476, Oct. 1953.

Author gives survey of literature on thermal properties of textiles covering the years 1930–1950. Discusses properties such as cold feel and chillproofness. Author concludes that thermal insulation depends largely on thickness, cold feel mainly on area of contact between fabric and skin, and chillproofness upon the water absorption and the heat of absorption of the material.

H. Kolsky, England

1505. **Sanborn, M. A., Irregularity in textile yarns and strands. A literature survey,** *Text. Res. J.* **24,** 1, 86–95, Jan. 1954.

1506. **Kägi, V. H., Stress-strain curves of fibrous materials: Textiles, leather, and paper** (in German), *Schweiz. Arch.* **19,** 12, 366–379, Dec. 1953.

Mechanics of Forming and Cutting

(See also Rev. 1442)

1507. **Billigmann, J., Upsetter and press forging. Handbook on hot and cold forming processes of steel and nonferrous metals in series and mass production [Stauchen und Pressen. Handbuch für die bildsame Kalt- und Warmformegebung von Stählen und Nichteisenmetallen in der Serien- and Massenfertigung],** München, Carl Hanser Verlag, 1953, xvi + 574 pp., 529 figs., 93 tables. DM 28.50.

This handbook integrates the wealth of recent scattered individual contributions into a whole. Essentially a reference book, it bypasses the analytical approach, known from contemporary theory of plasticity, but is, nevertheless, extremely systematical, logical, and complete and may well serve as a textbook for advanced students of the art of industrial forging.

Content covers materials (chemical and physical properties, commercial and manufacturing specifications and limits) and their testing, engineering data (thermal and mechanical) for planning of methods and operations in all detail, equipment (machines, furnaces, tools and dies, with design details) and processes (with many examples), finishing operations for pressed articles, and estimates of economy. Bibliography of 20 pages draws fairly evenly from American and German literature, whereas a list of standard specifications are exclusively of German origin (DIN).

Reviewer considers the book extremely valuable for production engineers; it will also be found very useful in various phases of industrial and applied research. E. K. Henriksen, USA

1508. **Frisch, J., and Thomsen, E. G., An experimental study of metal extrusions at various strain rates,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-154, 15 pp.

A 4.3-in.-diam cylindrical commercially pure lead billet was extruded at room temperature into a 1.5-in.-diam solid bar at three extrusion rates of 0.1, 0.74, and 5.15 in. per min. Particle velocities, magnitude, and direction for the inverted extrusion process using a sharp-edged die were determined on a meridian plane by a stepwise extrusion method. It was found that, for the extrusion rates investigated, the flow pattern was invariable with respect to the extrusion rates. Measured wall pressures were found to increase approximately linearly with the extrusion speed in a similar manner as the extrusion load, such that the average applied pressure to the wall pressures remained constant. Theoretical considerations appear to agree with experimental observations. The mean pressure within the metal differed from the measured wall pressure by the condition necessary to establish plastic flow. The predicted mean pressure obtained from a graphical analysis of the velocity pattern of the billet agreed approximately with measured mean pressure.

From authors' summary by W. Green, USA

1509. **Bishop, J. F. W., Calculations on sheet-drawing under back tension through a rough wedge-shaped die,** *J. Mech. Phys. Solids* **2,** 1, 39–42, Oct. 1953.

The slip-line field theory of Hill and Tupper [AMR 1, *Rev.* 1647] is used to determine the axial component of die load, back tension, and drawing stress when the reduction is such that the plastically deforming region extends over a finite portion of the axis and where velocity discontinuity along slip lines terminates at the die exit. It is assumed that distribution along die of the normal die pressure is composed of a constant part and a linearly increasing part. Empirical relationships are used for the magnitude of constant part and slope of increasing part. A back-pull factor is derived in terms of coefficient of friction, reduction, die semiangle, and back tension. Calculated values of back-pull factors for typical cases are found to be very close to those given by MacLellan's formula [*J. Iron Steel Inst.* **158,** 347–356, Mar. 1948] which is based on Sachs' theory of homogeneous deformation. D. Kececioglu, USA

1510. **Gräbner, R., Construction and use of overrunning grip rollers in machine tools** (in German), *Werkstatt u. Betrieb* **86,** 12, 733–737, Dec. 1953.

1511. **Balzer, H., Thread milling of short conical saw threads** (in German), *Werkstatt u. Betrieb* **85,** 7, 294–296, July 1952.

Author discusses two principal methods of holding material in order to cut short conical saw threads similar to those used in an ordinary drill chuck. The methods of holding the material are little different from those that would be devised by any tool engineer working on the problem. Extreme rigidity of the workpiece and precision milling of the threads are emphasized. The author claims simplification, higher production, and decreased milling-machine setup time when using the method.

Reviewer believes that although the general method is not new nor particularly novel, it is quite complete and is described in sufficient detail to warrant the article.

B. H. Amstead, USA

1512. Tobias, S. A., and Fishwick, W., The vibrations of machine-tool structures, *Engineering* **176,** 4584, 707–712, Dec. 4, 1953.

Investigation covers the important but often overlooked effect of machine-tool mountings on their vibration characteristics.

Experiments carried out on a heavy drilling-machine base plate to determine its frequencies and deflections under forced vibrations up to 80 cps are described. The methods of mounting included directly on the floor and on steel, felt, and rubber pads, the number of which was either 3 or 8. One series of experiments was carried out on concrete floor, the other on wood-block floors on a 3-in. concrete layer. Resonant frequencies, damping factors, and deflection curves are given. Analytical method for the determination of natural frequency of a freely supported beam resting on elastic supports is also given, and the effects "characteristic mass ratio" and "characteristic stiffness ratio" are investigated with the aid of graphs.

Results of experiments show that the resonant frequency was higher for the wooden floor than for concrete when the plate was mounted directly on floor. Authors suggest this type of mounting for structures with relatively high natural frequencies. Felt mountings should give good results for structures of low or very high natural frequencies.

In conclusion, authors rightly stress the importance of developing and testing machine structures upon mountings and foundations similar to those on which they are intended to work.

J. J. Dziewonski, England

1513. Rasmussen, R. E. H., On the examination of approximately straight edges (rules) and of approximately plane surfaces, *Trans. Dan. Acad. tech. Sci.* no. 1, 16 pp., 1953.

Hydraulics; Cavitation; Transport

(See also Revs. 1464, 1534, 1591, 1616, 1685)

1514. Li, W.-H., Open channels with nonuniform discharge, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 381, 20 pp., Jan. 1954.

Steady flows in an open channel with the addition of water along the course of flow are encountered frequently in engineering practice. Examples of this condition are the wash-water troughs in filters, the effluent channels around sewage-treatment tanks, and side-channel spillways. An equation based on the principle of conservation of momentum is derived in this paper. For cases in which the loss of energy because of friction is of secondary importance, solutions are obtained for prismatic channels of various cross sections and slopes. The hydraulic behavior of the flow is described with nondimensional quantities, and the validity of the theory is verified by tests on model channels.

From author's summary by H. J. Schoemaker, Holland

1515. Serre, F., Contribution to the study of permanent and nonpermanent flows in channels (in French), *Houille blanche* **8,** 3, 374–388, June-July 1953.

Author writes equations of back-water curves, taking into account curvature effects, by deducing the nonhydrostatic pressure distribution from the vertical acceleration and assuming the velocity distribution known and similar from section to section. [Reviewer notes that this starting analysis is close to Boussinesq, "Essai sur la théorie des eaux courantes," 1877.]

Author next introduces a generalized specific energy H (including curvature effects) and analyzes the general behavior of the solutions on a representative plane H and y (depth). First are studied those solutions approaching the point P of uniform regime; theory along the Poincaré-Lyapunov line leads to three cases: subcritical flow, mildly supercritical, and definitely supercritical; spiral-like curves around P are found only in the first two cases. The more difficult problem of the behavior at $y = \infty$ is next solved; curves approaching this point are shown to undulate while tending to $H = y$.

Reviewer finds this discussion new and stimulating.

A. Craya, France

1516. Holsters, H., Calculation of nonpermanent flow in rivers by the method known as "influence lines" (in French), *Houille blanche* **8,** 4, 495–509, Aug.-Sept. 1953.

The method of calculation of permanent flow called influence lines is a simplification of the exact method of characteristics; secondary inertial terms are usually ignored and a constant velocity of propagation is assumed. Paper studies the accuracy of the results, with numerical examples, regarding tidal waves; it is shown that the choice of too large depth and velocity is useful, since it leads to regularized profiles without modifying the form; on the contrary, choice of too small depths is to be avoided. Influence of secondary inertial terms is also analyzed.

D. Citrini, Italy

1517. Anonymous, Roughness standards for hydraulic models. Report no. 1. Study of finite boundary roughness in rectangular flumes, *Wwys. Exp. Sta. tech. Memo.* no. 2–364, 53 pp., June 1953.

The Manning roughness coefficient n was determined in water flumes 6, 12, and 24 in. wide for various kinds of artificial roughness, including brushed concrete, concrete ridges, concrete scored by metal stamps, pea gravel, expanded metal, etc. The results are presented graphically as well as in tabular form. Graphs of the familiar friction factor against Reynolds number show that the boundaries are in the rough range but do not produce lines for constant values of relative roughness as found for pipes. Although this work was primarily to obtain information to design river models, it is also of basic interest to the general flow-resistance problem.

V. A. Vanoni, USA

1518. Gladkov, V. A., and Urilov, M. K., Experimental coefficients of roughness of wooden pipe lines (in Russian), *Gidrotekh. Stroit.* no. 6, 26–28, June 1953.

Variations in friction and in conveyance caused by the growth of microorganisms were investigated in three wooden penstocks of about 68 inches in diameter. The friction factor in pipes brushed by hand was 0.0184 to 0.0236; after one year of use friction had increased to 0.0286 to 0.0288. In a penstock after 11 years in use without cleaning, this factor was 0.0316. Corresponding roughness coefficients were computed for exponential Pavlovskiĭ formula. Author concludes that carrying capacity of wooden penstocks drops 10 to 20% during first year of use; further decrease is more moderate.

S. Kolupaila, USA

1519. Ivanov, A. E., Carrying capacity of steel pipe lines (in Russian), *Gidrotekh. Stroit.* no. 5, 43–44, May 1953.

This is a discussion on an article by A. P. Palchevskiĭ in no. 5, 1952, of title source, dealing with the slurry transportation in dredge pipes. Several errors are disclosed and admitted by the author, who disregarded the pipe size.

S. Kolupaila, USA

1520. **Ghizzetti, A., edited by, Calculations for a water conduit with surge tank (Calcul des conduites d'eau avec cheminées d'équilibre)**, Paris, Gauthier-Villars, 1953, 78 pp., 12 diagrams.

Book includes a mathematical treatment on the theory of fluid oscillations in surge tanks. Conditions of equilibrium are set forth in a differential equation of the second degree whose solution involves seven parameters. Author has prepared charts of necessary functions to facilitate computations. The general solution includes the coefficient of resistance, so that it applies to a viscous fluid. Several practical examples are included, and some discussion is devoted to the solution of the very general problem of a conduit with n-surge tanks. No comparison of solutions obtained by the author with existing experience in actual installations is included; however, there is no question but that from the standpoint of initial design of surge-tank systems involving specified conditions, the author's solutions are preferable to the semi-empirical formulas used by many engineers.

J. M. DallaValle, USA

1521. **Weirich, H., Stability of oscillation in the differential surge tank** (in German), *Öst. Ing.-Arch.* **7**, 3, 236–243, 1953.

From the equation of motion for the oscillation in a differential surge tank under load, the author derives (for constant output and stable oscillation) two conditions satisfied by the surge-tank cross section. Conditions are found for the greatest possible output and for the friction loss in the tunnel when the load is thrown off and the oscillation is damped. Conditions are given for the smallest cross-section ratio and thus for the smallest admissible pipe cross section. A numerical example illustrates the results. From author's summary by F. Ursell, England

1522. **Weisser, C., Transport of water from deep wells by aid of turbine-driven centrifugal pump located underground** (in German), *ZVDI* **95**, 34, 1147–1150, Dec. 1953.

Radial or half-axial centrifugal pump submerged in a deep well is driven by a single- or multistage water turbine. Working water with pressures between 10–150 m is circulated by means of a motor-driven mother pump, situated above. The discharge of the well pump and the outflow from the turbine rise in common through a vertical mantle pipe and, on the ground, the flow is divided into a part which circulates and a part which (by means of another pump) is delivered to the supply. The influence of changing ratio between these two water quantities and of different pressure heads on the efficiency η of the whole installation is calculated. The article does not deal with the general conditions of balance on the turbine-pump axis but gives some characteristic curves (Q, H, N, n, η) for a given set, Voith-Kriegbaum type 8A.

O. Maštovský, Czechoslovakia

1523. **Mints, D. M., Velocity of impeded precipitation of solid particles in a fluid** (in Russian), *Gidrotekh. Stroit.* no. 5, 24–28, May 1953.

Author finds dependence of velocity of impeded precipitation of particles on concentration of water mixture on basis of study of suspension of grainy layer in rising flow of fluid. Comparison of drag coefficient of suspended grainy layer and drag coefficient of single grain for free settling in an unlimited volume yields relation for drag coefficient limit, $\eta_{\text{lim}} - \eta_0/\pi$. Author assumes dependence of drag coefficient on Reynolds number, for all Re, as $\eta = C/Re + \eta_0/\pi$ where $C = f(Re)$ is determined empirically from tests. Curves are given of dependence of ηRe vs. Re which, it is claimed, shows validity of theoretical assumptions. It is concluded that velocity of impeded precipitation drops abruptly with increasing concentration/volume of water mixture. Also influence of concentration increases as particle size decreases.

Reviewer's English translation of this article is on file with the Scientific Translations Division, Library of Congress.

M. D. Friedman, USA

1524. **Boreli, M., Study of a flow with axial symmetry in a porous medium: Case of a well not reaching the bottom** (in French), *C. R. Acad. Sci. Paris* **237**, 23, 1490–1491, Dec. 1953.

Solution by relaxation method. A. L. Jorissen, USA

1525. **Parmakian, J., Vibration of the Grand Coulee pump-discharge lines,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-50, 6 pp.

This paper describes a program of field tests, analyses, and modifications at the Grand Coulee Pumping Plant which were made to reduce the periodic vibration of the exposed sections of the pump-discharge lines. The source of the discharge-line vibration was traced to pressure oscillations originating in the pump. The vibration of the discharge lines subsequently was reduced to acceptable limits by a series of modifications of the pumps and discharge lines. From author's summary

1526. **Anonymous, Flood-control project for Allentown, Pennsylvania,** *Wwys. Exp. Sta. tech. Memo.* 2-376, 13 pp., Dec. 1953.

Proposed improvement plans designed to reduce flood damage at Allentown, Pa., were tested in a fixed-bed model constructed to linear scale ratios of 1:150 horizontal and 1:50 vertical. The model reproduced approximately 3 miles of the Lehigh River channel at Allentown, and 1 mile each of Little Lehigh and Jordan Creeks. The confluence of these creeks is in a highly industrialized area just upstream of Little Lehigh Creek's entrance into a back channel of Lehigh River behind Kline's Island.

From summary

1527. **Smith, I. D., A detailed report on the controls and indicators of the Fraser River Model,** *Nat. Res. Counc. Canad. mech. Engng., Rep.* MH-41, 76 pp., May 1953.

Incompressible Flow: Laminar; Viscous

(See also Revs. 1560, 1562, 1568)

1528. **Alexander, L. G., Baron, T., and Comings, E. W., Transport of momentum, mass, and heat in turbulent jets,** *Univ. Ill. Engng. Exp. Sta. Bull.* no. 413, 88 pp., 1953.

Bulletin presents results of experimental and analytical investigation of transport phenomena in subsonic turbulent jets. After reviewing Prandtl's momentum-exchange theory, Taylor's vorticity-transport theory, and the empirical formulations of Boussinesq and Reichardt, authors conclude that Reichardt's hypothesis [*J. roy. aero. Soc.* **47**, p. 167, 1943] offers best possibilities for generalization and application. This hypothesis linearizes the axial momentum equation and produces probability-type mean velocity distribution which correlates well with experimental results. Authors thereupon generalize Reichardt's hypothesis and derive expressions for the distri ution of flux of any quantity in a turbulent jet. Linearization permits summation or integration of elementary point-source jets to obtain theoretical profiles for boundary conditions less simple than those of the single point-source jet.

Experimental portion describes results of impact-tube surveys of single jets of varying diameter and discharge velocity, two parallel jets, and a jet discharging parallel to a wall. Agreement with analytical results is generally good except in region of

transition to fully developed turbulence, where momentum flux is slightly underestimated. Although only isothermal jet data were obtained in this investigation, temperature distribution data obtained by other investigators are found to be in good agreement with results based on Reichardt's extended hypothesis.

Success of extended analysis in predicting macroscopic structure of free jets encourages belief that Reichardt's hypothesis, or modifications thereof, may be useful in other problems involving free turbulence. W. E. Moeckel, USA

1529. Plesset, M. S., On the stability of fluid flows with spherical symmetry, *J. appl. Phys.* **25,** 1, 96–98, Jan. 1954.

The conditions for the stability or instability of the interface between two immiscible incompressible fluids in radial motion are deduced. The stability conditions derived by Taylor for the interface of two fluids in plane motion do not apply to spherical flows without significant modifications.

From author's summary

1530. Kawaguti, M., Numerical solution of the Navier-Stokes equations for the flow around a circular cylinder at Reynolds number 40, *J. phys. Soc. Japan* **8,** 6, 747–757, Nov.-Dec. 1953.

Viscous flow past a circular cylinder becomes unstable at about Reynolds number 40. To investigate critical range, author integrates numerically exact Navier-Stokes equations at this value. He shows that steady solution exists, that it appears to go over smoothly to solution for discontinuous flow, and he obtains good agreement with experiment. Maurice Holt, England

1531 Truesdell, C., Precise theory of the absorption and dispersion of forced plane infinitesimal waves according to the Navier-Stokes equations, *J. rational Mech. Anal.* **2,** 4, 643–741, 1953.

This memoir concerns the hydrodynamical theory of plane waves of infinitesimal amplitude in pure fluids. First, an outline and critical review are given of the existing theories of the absorption and dispersion of plane sound waves of infinitesimal amplitude, ranging from the classical work of Stokes, Stefan, Kirchhoff, and Langevin to the more recent relaxation and hydrodynamical theories, with some 90 references to the literature. Then the author presents a complete treatment of the single-fluid (viscothermal) case by deriving and fully interpreting the exact solutions of the characteristic equation of Kirchhoff and Langevin for the propagation of sound waves in a fluid when both heat conduction and viscosity are taken into account. The mathematical analysis is supplemented by many tables and graphs in terms of three dimensionless parameters: The ratio γ of the principal specific heats of the fluid, its thermoviscous number Y (the reciprocal of the product of the Prandtl number by the viscosity number), and the frequency number X (which is proportional to the frequency of the wave motion). R. Heller, USA

1532. Szebehely, V. G., and Niederer, O. C., Unsteady and amplitude effects on the moment derivatives of a prolate spheroid, *David W. Taylor Mod. Basin Rep.* 828, 24 pp., Dec. 1953.

Free yawing oscillations of 9-ft long prolate spheroid with fineness ratio l/d seven to one have been measured with model running at constant depth-diam ratio $h/d = 3.08$ at speeds varying from 0 to 4 knots. Tests results have been evaluated on assumption of motion governed by linear differential equation.

Added moment of inertia of spheroid found by experiments agrees well with theoretical formula. Frequency did not vary with amplitude of oscillation. But damping was not constant and was found to vary with frequency and with amplitude. No attempt seems to have been made to find another law of damping than the one governed by the linear equation, e.g., with linear and quadratic damping. Results regarding hydrodynamic restoring moment are rather uncertain because this moment was small in comparison with spring restoring moment of instrument and was obtained as difference between large quantities.

Suggestions are made for future research.

G. Vedeler, Norway

1533. Kolin, A., Demonstration of parabolic velocity distribution in laminar flow, *Amer. J. Phys.* **21,** 8, 619–620, Nov. 1953.

A simple electrochemical method is used to demonstrate visually the parabolic velocity profile characteristic of Poiseuille flow. An opaque blue cloud, created by a starch-iodine reaction at a wire passing across the tube, is subsequently stretched into a parabola by the flow. Use of a glycerine solution whose refractive index approximates that of the lucite tube minimizes optical distortion. Actual measurements on a photograph give agreement with the parabolic law, the results showing rather small dispersion. The experiment makes an effective lecture demonstration, particularly if performed sequentially with similar experiments of the Reynolds type demonstrating the breakdown of the Poiseuille flow and transition to turbulence. D. Bershader, USA

1534. Berman, A. S., Laminar flow in channels with porous walls, *J. appl. Phys.* **24,** 9, 1232–1235, Sept. 1953.

The effect of wall porosity on the two-dimensional steady-state incompressible laminar flow of a fluid in a channel having rectangular cross section has been investigated in detail by the solution of the Navier-Stokes equations.

With the assumption of uniform suction at the walls, an exact solution of the flow equations is obtained, leading to a third-order nonlinear differential equation with appropriate boundary conditions. For small flows through the porous walls, this latter equation is solved by a perturbation method. First-order expressions for the dependence of the velocity components and the pressure on positional coordinates, channel dimensions, and fluid properties are obtained.

The velocity "profile" in the major flow direction is found to deviate from the Poiseuille parabola by being flatter at the center of the channel and steeper in the region close to the walls, the degree of deviation depending on a Reynolds number for the flow through the channel walls.

The pressure drop in the direction of the main flow is found to be appreciably less in the porous wall channel than that in a solid wall channel having the same dimensions and the same entrance Reynolds number.

From author's summary by G. H. Lean, England

1535. Itô, H., Theory of laminar flow through a pipe with nonsteady pressure gradients, *Rep. Inst. high speed Mech. Tōhoku Univ.* **3,** 163–180, Mar. 1953.

Author studies, by means of Laplace transforms, the initial value problem of the flow in a long pipe of uniform cross section when a pressure difference is applied between two sections of the pipe. Three particular cases are treated: (a) The initial state ($t = 0$) is Poiseuille flow and the pressure difference varies linearly with the time for $t > 0$; (b) the initial state is again Poiseuille flow and the pressure gradient is changed instantaneously to a new constant value; (c) the fluid is initially at rest and a pressure gradient in the form of a damped harmonic oscillation in time is applied for $t > 0$.

Author's use of the transform is somewhat confusing. Al-

though, in cases (a) and (b), the initial value of the velocity u does not vanish, the term expressing this initial velocity is not included in the transform of $\partial u/\partial t$. This error is evidently corrected during the process of inverting the transform by adding the appropriate term, but it is not clear where this is done because the actual inversion is not discussed.

For previous work on the same problem using the same method, see Gerbes [AMR 5, Rev. 2657], who treats somewhat different particular cases. G. W. Morgan, USA

1536. **Baron, T., Sterling, C. S., and Schueler, A. P., Viscosity of suspensions—review and application to two-phase flow,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 103–128, 1953.

A majority of separation processes and some reaction processes involve the simultaneous flow of two or more phases.

The different types of multiphase flow, stratified flow, annular flow, slug flow, and dispersed flow, as well as the conditions of transition between the various types of flows, present a number of problems. In the present work, consideration is restricted to incompressible multiphase dispersed flow, and, in particular, the conditions under which such flow can be treated is investigated with the techniques developed for single-phase flow. From a proposed criterion, sufficient conditions for the applicability of this technique are derived. Various theories of the viscosity of suspensions are briefly reviewed. Finally, some data bearing on the argument are presented. From authors' summary

Compressible Flow, Gas Dynamics

(See also Revs. 1374, 1555, 1556, 1558, 1573, 1603, 1636, 1640

1537. **Kainer, J. H., A simplified method to obtain the load distribution corresponding to the Ackeret region for wings having arbitrary source distribution at supersonic speeds,** *J. aero. Sci.* 20, 11, 749–750, Nov. 1953.

Author shows that, for a wing with swept leading edge, the potential at any point P_1 ahead of the Mach line from the leading-edge apex is obtained from the potential for a point P within the aftercone of the leading-edge apex by retaining only the pure real expressions when the coordinates of P are replaced by those of P_1.

This provides a simple means of obtaining the potential in the Ackeret region between the supersonic leading edge and the Mach line from the leading-edge apex. Such potentials are necessary to evaluate the loading on swept and triangular wings by a method described by the author [AMR **7**, Rev. 881].

S. Kirkby, England

1538. **Delany, N. K., and Sorensen, N. E., Low-speed drag of cylinders of various shapes,** *NACA TN* 3038, 22 pp., Nov. 1953.

Test data were obtained for cylinders of circular, elliptical, rectangular, diamond, and isosceles triangular shapes with the range of Reynolds number of 11,000 to 2,300,000. For some cylinders, frequencies of pressure fluctuations in the wake were measured. T. H. Lin, USA

1539. **Miles, J. W., A note on subsonic edges in unsteady supersonic flow,** *Quart. appl. Math.* **11**, 3, 363–367, Oct. 1953.

Author's theory for oscillating wings with straight edges [AMR 7, Rev. 225] is completed by construction of general solution appropriate to subsonic trailing edges at which Kutta condition is satisfied. G. N. Ward, England

1540. **Heinz, C., Supersonic flow past slender bodies** (in German), *ZAMM* **33**, 8/9, 306–308, Aug./Sept. 1953.

Integrals of the type that appear in von Kármán's familiar integral equation (*) of slender-body theory and the associated pressure formula are rewritten by means of a transformation of variables and their kernels are approximated by polynomials. The result is to convert (*) into a differential equation, for example. W. R. Sears, USA

1541. **Kahane, A., and Solarski, A., Supersonic flow about slender bodies of elliptic cross section,** *J. aero. Sci.* **20**, 8, 513–524, Aug. 1953.

A theory for slender bodies of elliptic cross section in supersonic flow, based on the generalized cross-section slender-body theory of Ward [AMR **3**, Rev. 529] is presented. The theory is applied to the zero-angle-of-attack pressure distribution on elliptic cones and parabolic-arc bodies of elliptic cross section; results of several example computations are presented. Comparison is made with the nonlinear elliptic-cone calculations and experimental results of Ferri [AMR **5**, Rev. 1137]; good agreement is obtained. The wave drag of bodies with elliptic bases is also treated. Application of the theory to bodies at angle of attack is indicated.

From authors' summary by L. Goland, USA

1542. **Probstein, R. F., On the flow at the rear of a two-dimensional supersonic airfoil with thickness,** *J. aero. Sci.* **20**, 8, 580–581, Aug. 1953.

Incorrect results of Kahane and Lees [AMR **1**, Rev. 694], giving dynamic pressure changes through isentropic and shock waves as power series in the flow deflection angle, are corrected. Correction is also given for flow deflection at rear of a supersonic profile with thickness. A. H. Shapiro, USA

1543. **Ferri, A., Ness, N., and Kaplita, T. T., Supersonic flow over conical bodies without axial symmetry,** *J. aero. Sci.* **20**, 8, 563–571, Aug. 1953.

The flow over a nonaxially symmetric conical body is computed, assuming that it is a small perturbation about the flow over a cone of circular cross section. The effect of the perturbation (only the first-order perturbations are considered here) is represented by a superposition of conical solutions. The procedure is then used to compute the flow over cones of elliptical, drop shape, and triangular cross sections.

In procedures such as the present there always arises the generally unanswerable question of convergence; specifically in the present case (assuming that the procedure is convergent), one has the question concerning the class of deviations of the body shape from the circular cone which may be permitted within the first-order theory. H. Yoshihara, USA

1544. **Ferrari, C., Determination of the external contour of a body of revolution with a central duct so as to give minimum drag in supersonic flow, with various perimetral conditions imposed upon the missile geometry,** *Cornell aero. Lab. Rep.* AF-814-A-1, 6 pp., Mar. 1953.

Linear theory is used to determine external contour for which the external drag is a minimum when either the area or volume between the sought-for external contour and a chosen internal contour has a prescribed value. Flow through duct is not considered. Assumed, however, is that the duct is nearly a cylinder or else that the shape which the external duct contour is built upon is almost the frustrum of a cone. Trailing edge of duct is not blunt.

Two methods are used; one is based on application and exten-

sion of Lighthill's work ["Supersonic flow past bodies of revolution," *Aero. Res. Counc. Rep. Mem.* 2003, 1945]; the other makes use of a distribution of supersonic sources. Both methods are used to obtain solution for all cases treated. First method leads to a nonhomogeneous integral equation of the second kind; the second method to an integral equation of the first kind. Numerical applications for formulas derived are promised for a following report.
N. Tetervin, USA

1545. Woods, L. C., The theory of aerofoils with hinged flaps in two-dimensional compressible flow, *Aero. Res. Counc. Lond. curr. Pap.* no. 138, 32 pp., Aug. 1952, published 1953.

Paper presents a theory of the hinged flap in two-dimensional compressible flow. Basic mathematical theory starting with equations of motion in hodograph plane is given. The effect of compressibility and thickness of the airfoil on the control characteristics is given in a simple form. An example is included.
G. V. R. Rao, USA

1546. Keune, F., On the subsonic, transonic and supersonic flow around low aspect ratio wings with incidence and thickness, *Roy. Inst. Technol., Div. Aero. TN* 28, 32 pp., 1953.

For a small aspect ratio, the determination of flow over a wing reduces to a solution of Laplace's equation in two dimensions for each wing section normal to free-stream direction, except for a "spatial" influence due to the area of these sections. Usual treatment [*NACA TN* 1032, AMR **6**, Rev. 3508] makes further assumption that ratio of wing thickness to span is small. Present paper gives second-order terms in development with respect to this ratio. These terms are independent of Mach number. Detailed formulas and examples are worked out, and flow in the vicinity of a rounded leading edge is investigated. For the lift the influence of these corrections is small, but for other aerodynamical data they are of importance. G. Guderley, USA

1547. Bergman, S., Methods for the determination of subsonic flows around profiles, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 705–713, 1952.

A highly condensed and theoretical account of how the author's kernel-function method of solving certain partial differential equations can be used for three types of adiabatic subsonic flow: (1) In a strip bounded on one side by a straight line and on the other by segments of straight lines joined up by free streamlines; (2) symmetric and nonsymmetric flow past an airfoil; (3) axially symmetric flows. Only an outline of the method is given, with no numerical details. Author states that the computations are long but are well adapted to punch-card machines or other modern computational machines. J. C. Cooke, British Malaya

1548. Ferri, A., The linearized characteristics method and its application to practical nonlinear supersonic problems, *NACA Rep.* 1102, 18 pp., 1952.

Supersedes article reviewed in AMR **5**, Rev. 1137.

1549. Harrop, R., Bright, P. I. F., Salmon, J., and Caiger, M. T., The design and testing of supersonic nozzles, *Aero. Res. Counc. Lond. Rep. Mem.* 2712, 40 pp., May 1950, published 1953.

The flow near the throat of a supersonic nozzle is analyzed by a perturbation method. The sonic line is shown to be curved. The line on which the Mach number = 1.20 is then chosen as an initial curve for the design of several supersonic nozzles by the method of characteristics. Experimental calibrations are given for 3-in. nozzles designed by this process. Methods of correcting these nozzles are also applied, resulting in test-section Mach-number distributions which are constant, in some cases, to about $\pm 0.5\%$.
L. H. Schindel, USA

Turbulence, Boundary Layer, etc.

1550. Uberoi, M. S., Correlations involving pressure fluctuations in homogeneous turbulence, *NACA TN* 3116, 61 pp., Jan. 1954.

First part of paper is concise derivation of relationships between pressure-velocity correlations and fourth-order velocity correlations for two points. A general expression linking correlations of pressure and a given quantity with velocity components and the same quantity are presented for homogeneous turbulence. Several examples are developed therefrom.

Most of the paper is devoted to a particular case of isotropic turbulence and the development and verifiation of a hypothesis relating second- and fourth-order correlations. This is deduced by assuming a Gaussian joint probability distribution but is not dependent on this assumption. Several relationships between second- and fourth-order velocity and pressure correlations are deduced. Most of these have been derived before, but author points out mistakes made by previous investigators. Most important part of the paper is presentation of measurements of second- and fourth-order velocity correlations by a new hot-wire technique. All results verify the hypothesis. Root-mean-square pressure and pressure gradient are computed from experimental data and compare well with theoretical values.
W. D. Baines, Canada

1551. Corrsin, S., and Kistler, A. L., The free-stream boundaries of turbulent flows, *NACA TN* 3133, 109 pp., Jan. 1954.

An experimental and theoretical study has been made of the instantaneously sharp and irregular front which is always found to separate turbulent fluid from contiguous "nonturbulent" fluid at a free-stream boundary. This distinct demarcation is known to give an intermittent character to hot-wire signals in the boundary zone.

The over-all behavior of the front is described statistically in terms of its wrinkle-amplitude growth and its lateral propagation relative to the fluid as functions of downstream coordinate.

It is proposed and justified that the front actually consists of a very thin fluid layer in which direct viscous forces play the central role of transmitting mean and fluctuating vorticity to previously nonturbulent fluid. Outside this "laminar superlayer" there is presumably a field of irrotational velocity fluctuations (the nonturbulent flow) with constant mean velocity. Theoretical analysis based on this general physical picture gives results on front behavior which are in plausible agreement with experimental results for three turbulent shear flows: rough-wall boundary layer, plane wake, and round jet.
From authors' summary by L. S. G. Kovasznay, USA

1552. Cavers, S. D., Hsu, N. T., Schlinger, W. G., and Sage, B. H., Temperature gradients in turbulent gas streams, *Indust. Engng. Chem.* **45**, 10, 2139–2145, Oct. 1953.

In consideration of the characteristics of the turbulence of the flow in a duct, it has been common practice to distinguish three different regions, namely, the turbulent core comprising the great majority of the duct cross section; second, the layer very close to the wall where the flow is completely laminar; and third,

the transition or buffer region between the laminar and turbulent regions. This transition region is generally assumed to correspond to values of 5 to 30 for the dimensionless distance known as y^+.

This paper presents correlations of results of very extensive and carefully conducted tests, covering this transition region, for a flat duct, (i.e., flow which is essentially two-dimensional); the duct was long enough to give a fully developed velocity profile. One duct wall was heated, the other cooled so that heat flowed across the flowing gas; the measurements were made far enough from the entrance so that there was negligible axial variation of the temperature profile. The range of the diameter Reynolds number was 6000 to 55,000. The turbulence characteristics are presented in the form of values of eddy conductivity and of eddy viscosity. Paper is a convenient summary of the significant results reported in several recent more detailed papers by some or all of the present authors.

One significant feature of the results is that the eddy conductivity, for all the Reynolds numbers and all the positions relative to the duct wall in the regions considered, can be correlated by a single smooth curve. This curve is plotted with the distance parameter y^+ as one coordinate and a function of eddy conductivity, thermal diffusivity, and the position relative to the wall as the other coordinate.

Another significant feature of the results is that this curve shows no sharp change of slope at the supposed boundary between the transition region and the fully turbulent region (y^+ near 30). Theoretical equations which do show such a change of slope did not deviate very far, however, from the test results, provided certain constants in the equations are established empirically from these tests.

The ratio of eddy viscosity to eddy conductivity, known as the total Prandtl number, is found to vary appreciably with Reynolds number and position relative to the wall; it varies from about 0.6 to about 0.93 for the range of parameters considered. The experimentally determined total viscosity ranged from slightly more than the theoretical to about 25% less.

This reviewer considers that the results are likely to prove particularly useful for predicting temperature profiles when an arbitrary distribution of wall temperature is given, different from the simple distribution one used in the test, under conditions where the authors' assumption that the eddy viscosity and eddy conductivity are unaffected by the temperature variations is a reasonable approximation. R. H. Norris, USA

1553. Roshko, A., On the development of turbulent wakes from vortex streets, *NACA TN* 2913, 77 pp., Mar. 1953.

This is a contribution most timely and significant in view of the present widespread interest in the nature and characteristics of motion of discrete eddies and in the larger problems pertaining to the origin of turbulence. Dr. Roshko's report, based upon exhaustive measurements and analysis of both periodic and random fluctuations in the wake of circular cylinders, adds essential facets to the understanding of the nature of drag of blunt bodies. Shedding frequencies of eddies, i.e., Strouhal numbers, are determined over a wide Reynolds number range, this relation being such that eddy frequencies may serve as a basis for velocity measurement. Three subranges are identified according to frequency stability and distinctive interaction of periodic eddy and turbulent motion. The analysis contains useful extensions to periodic oscillations of certain functions thus far applied to random oscillations only. The results suggest further fruitful studies of the interaction of discrete vortexes and turbulent motion.

J. R. Weske, USA

1554. Dannenberg, R. E., Weiberg, J. A., and Gambucci, B. J., The resistance to air flow of porous materials suitable for boundary-layer-control applications using area suction, *NACA TN* 3094, 21 pp., Jan. 1954.

The pressure-drop vs. flow-rate characteristics of permeable materials of interest in boundary-layer-control applications were measured over a wide range of pressure differentials. Sintered metals, filtered material, and perforated sheets were tested. The pressure-drop vs. velocity law was almost linear for the high-density materials and almost quadratic for the low-density and perforated materials until mass choking effects dominated at high pressure drops. P. A. Libby, USA

1555. Morris, D. N., and Smith, J. W., The compressible laminar boundary layer with arbitrary pressure and surface temperature gradients, *J. aero. Sci.* **20,** 12, 805–818, Dec. 1953.

The von Kármán-Pohlhausen method is extended systematically to cover the hitherto unsolved problem of two-dimensional compressible laminar flow with arbitrary surface temperature and pressure gradients and arbitrary but constant Prandtl number. Application of the present method to the calculation of heat transfer and skin friction in a given case involves the numerical integration of two simultaneous ordinary differential equations, which is readily accomplished by hand or with an automatic digital calculator. The theory is well adapted to an investigation of the combined effect of pressure and surface temperature gradients in the compressible boundary layer for which no other practical method is available.

Solutions by the present method are compared with more exact solutions in the special cases for which the latter are available, and the agreement is good in all cases.

From authors' summary by C. C. Lin, USA

1556. Li, T.-Y., and Nagamatsu, H. T., Similar solutions of compressible boundary-layer equations, *J. aero. Sci.* **20,** 9, 653–655, Sept. 1953.

The compressible boundary-layer equations are integrated numerically for certain conditions. A ratio of heat-transfer and friction coefficients is plotted for various surface temperatures with different free-stream pressure gradients.

R. C. Binder, USA

1557. Oudart, A., Three-dimensional boundary layer (in French), *C. R. Acad. Sci. Paris* **237,** 14, 697–698, Oct. 1953.

Short note discusses the criteria for separation in laminar and turbulent layers. A method is outlined, based on the potential flow and generalizing the method of Karl Pohlhausen.

R. Betchov, USA

1558. Moore, F. K., Three-dimensional laminar boundary-layer flow, *J. aero. Sci.* **20,** 8, 525–534, Aug. 1953.

Some general conclusions concerning steady three-dimensional boundary-layer behavior are inferred from detailed consideration of the particular case of the boundary-layer flow on a cone at angle of attack in a supersonic stream.

Qualitative features of the cone boundary layer are discussed and solutions are given for two cases. In the first, the angle of attack is assumed small and thickening of the boundary layer on the lee side of the cone is indicated but no separation occurs. In the second, consideration is restricted to the plane of symmetry of the flow and no restriction is placed on the angle of attack. On the lee side of the cone, unique solutions are limited to small angle of attack, and beyond a particular angle of attack the boundary layer cannot remain thin.

The concepts of displacement thickness and flow separation are generalized to three dimensions, and failure of the thin boundary-layer assumptions is related to the formation of strong vortexes in a separated region for laminar, or more tentatively, turbulent flow. From author's summary by N. Tetervin, USA

1559. Granville, P. S., The calculation of the viscous drag of bodies of revolution, *David W. Taylor Mod. Basin Rep.* 849, 45 pp., July 1953.

Method is based on boundary-layer momentum equation for incompressible flow together with convenient assumptions for the velocity profiles and the skin friction in laminar flow and in turbulent flow. Boundary-layer momentum equation is integrated and given in a form convenient for calculation. Calculation proceeds from pressure distribution by first calculating the laminar boundary-layer thickness to the transition point, then the thickness of the turbulent boundary layer to the tail, then the momentum thickness far behind the body. Drag is known when this momentum thickness is known. Method contains many approximations but appears to give good results for the drag.

To determine the transition point, a new procedure was developed; it consisted in plotting the difference between the boundary-layer Reynolds number at transition and the boundary-layer Reynolds number for neutral stability against the average nondimensional pressure gradient in the region from the neutral stability point to the transition point. The few data plotted seem to fall on one curve. This curve is used to determine the transition point in a specific case. N. Tetervin, USA

1560. Schlichting, H., Laminar flow about a spinning body of revolution in an axisymmetric stream (in German), *Ing.-Arch.* **21**, 227–244. 1953.

Author applies Pohlhausen's method to find approximate solutions of incompressible boundary-layer equations for spinning nonyawing body of revolution. He approximates meridional (azimuthal) velocity profile by fourth-degree polynomial in $t = z/\delta_x$ ($t' = z/\delta_y$) where z is distance normal to body and $\delta_x(\delta_y)$ is meridional (azimuthal) boundary-layer thickness. The meridional polynomial contains a shape parameter proportional to δ_x^2 by a factor that depends on the shape of the body, the nonviscous velocity distribution, and the angular velocity. The momentum equations and these profiles yield a system of first-order nonlinear ordinary differential equations for the meridional momentum thickness and an "angular" momentum thickness. The system has been integrated numerically, and drag and axial moment coefficients, etc., have been found for a disk, sphere, half body, and conventional and low-drag laminar-flow fuselages. Results for the disk agree well with earlier calculations by a different method [AMR **6**, Rev. 186]. Calculated axial moments vary only slightly; drags increase appreciably with spin. Spin also imparts greater drag to the laminar-flow body than to the conventional body. J. H. Giese, USA

1561. Tifford, A. N., and Chu, S. T., The laminar boundary layer on spinning axisymmetric bodies, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 579–592, 1953.

The analysis is developed for a fluid with constant viscosity and heat conductivity, reference being made to a previous paper in which it is claimed that the results can be made applicable to compressible flow. The equations of motion, continuity, and energy are developed for the boundary layer with extensions of the usual assumptions, and the energy equation is replaced by two equations on the assumption of the independence of the viscous and heat-transfer contributions to the enthalpy. It is concluded that the rate of heat transfer is proportional to the spinning torque when (a) the Prandtl number is of the order of unity; (b) the body, if not a cone, is not very thick; (c) there is a linear relation between the moment of angular momentum at the surface and the difference between the surface temperature and its temperature if it were insulated; and (d) the order of magnitude of the spin speed is not greater than that of the free-stream velocity. If the spin speed is small compared with the free-stream velocity it is argued that the nonspinning aspects of the boundary layer are unaffected by the rate of spin and hence can be related by the Mangler transformation to a corresponding two-dimensional boundary-layer flow. The reviewer feels that the paper is overcondensed for the ground it is intended to cover.

A. D. Young, England

Aerodynamics of Flight; Wind Forces

(See also Revs. 1399, 1544, 1559, 1608, 1612, 1653)

1562. Rauscher, M., Introduction to aeronautical dynamics, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, xv + 664 pp. $12.

One of the important tasks of an aeronautical engineer is the analysis of the disturbed motion of an airplane under the equilibrium of fluid and inertial forces. Thus, to students of aeronautics, the two branches of applied mechanics, i.e., solid mechanics and fluid mechanics, are not separate subjects. As a result, there is a need for books which combine a discussion of the fundamental principles of both branches with a special emphasis on their application to the problems of aeronautical engineering. Professor Rauscher has written an undergraduate text which meets these requirements exceptionally well and which has no rival in English.

Author begins with particle dynamics and then branches into fluid- and rigid-body dynamics, respectively. The fourteen chapters are divided equally between the two branches in the following order: Kinematics of a point, Dynamics of a particle, Dynamics of groups of particles, Fundamental equations of fluid motion, Stream function and velocity potential, Fluid motion about simple bodies, Transformations, Airfoils, Airfoils in three dimensions, Viscosity, Kinematics of rigid bodies, Dynamics of rigid bodies, Oscillations of systems with one degree of freedom, and, finally, Oscillations of systems with more than one degree of freedom. As the author indicates, this equal division would permit the use of one half of the text for a course in solid dynamics, while the remaining chapters would serve for a course of equal length in fluid dynamics alone.

Each topic is discussed in great detail as, for example, in the development of the fundamental equations of fluid dynamics where alternative approaches are included for comparison. The illustrative examples which the author includes are pertinent and aptly designed to stimulate the student's interest. The study of aircraft maneuvers by means of flight records and ground observations and the analysis of rocket propulsion and flight provide ideal examples in particle dynamics. In the chapter on the dynamics of rigid bodies the author includes a discussion of a moving airplane with revolving propellers as a supplement to the fundamental discussion on gyrodynamics. Both the theory and the application are strengthened by this close coupling.

Author assumes that the student has knowledge of only introductory calculus. Any higher mathematics is fully discussed when the need arises, as, for example, functions of a complex variable in conjunction with the conformal transformations of airfoils and Fourier series in the chapter on three-dimensional airfoil theory. In presenting the oscillation problems the author also includes a discussion of methods of solving linear differential equations with

constant coefficients together with a review of determinants. Thus he has kept in mind the student engaged in independent study or review. Author has, however, avoided the use of vector notation and analysis on the ground that few engineering students have an adequate knowledge of vector operations in their junior year.

This text is the product of the author's 22 years of teaching and research at the Massachusetts Institute of Technology, and the order of the subject matter corresponds to the classroom sequence at the Institute, although the present approach is somewhat different. Author frankly admits his failure to include some of the topics which are now of importance to aeronautical engineers. Reviewer hopes that some discussion of thin-airfoil theory, of airfoils in compressible flow, and of stability conditions for oscillating systems will be included in the subsequent editions which this work justly deserves.

The format of this book is worth special mention. The large pages are set in a clear type and the subheadings and equations stand out from the text. Also, the illustrations are numerous and effective. T. H. H. Pian, USA

1563. **Heaslet, M. A., and Spreiter, J. R., Reciprocity relations in aerodynamics,** *NACA Rep.* 1119, 16 pp., 1953.

Supersedes article reviewed in AMR **6,** Rev. 988.

1564. **Kapryan, W. J., and Boyd, G. M., Jr., The effect of vertical chine strips on the planing characteristics of V-shaped prismatic surfaces having angles of dead rise of 20° and 40°,** *NACA TN* 3052, 38 pp., Nov. 1953.

The effect of vertical chine strips on the planing characteristics of two prismatic surfaces having angles of dead rise of 20° and 40° has been determined as part of a general research investigation on planing surfaces. Wetted lengths, resistance, and center-of-pressure location were determined at speed coefficients up to 25.0, load coefficients up to approximately 80.0, and trims up to 30°. In addition, comparisons of the more important planing characteristics are made with those for related surfaces having angles of dead rise of 0°, 20°, and 40°, and for surfaces having angles of dead rise of 20° and 40° with horizontal chine flare. These comparisons show that vertical chine strips are a more effective means of increasing the lift of a given surface than horizontal chine flare is. This increase in lift, however, is accompanied by a substantial increase in drag so that the lifting efficiency of the vertically flared surface is comparable to one having horizontal chine flare.

From authors' summary by M. S. Macovsky, USA

1565. **Diederich, F. W., and Zlotnick, M., Calculated spanwise lift distributions and aerodynamic influence coefficients for unswept wings in subsonic flow,** *NACA TN* 3014, 120 pp., Sept. 1953.

Spanwise lift distributions have been calculated for 19 unswept wings with various aspect ratios and taper ratios and with a variety of angle-of-attack or twist distributions, including flap and aileron deflections, by means of the Weissinger method with eight control points on the semispan. Also calculated were aerodynamic influence coefficients which pertain to a certain definite set of stations along the span, and several methods are presented for calculating aerodynamic influence coefficients for stations other than those stipulated.

The information presented herein can be used in the analysis of untwisted wings or wings with known twist distributions, as well as in aeroelastic calculations involving initially unknown twist distributions.

From authors' summary by S. Lampert, USA

1566. **Bobbitt, P. J., and Malvestuto, F. S., Jr., Estimation of forces and moments due to rolling for several slender-tail configurations at supersonic speeds,** *NACA TN* 2955, 71 pp., July 1953.

This paper is chiefly concerned with the effects of various tail configurations on the lateral dynamic stability of aircraft and missiles at supersonic speeds. Its purpose is twofold; accordingly, the rolling and yawing moments due to rolling are determined for a number of practical slender-tail arrangements, and then the method used in solving the problem of the rolling two-dimensional boundary, first reported by W. G. Bickley, is presented.

The general analysis applies the familiar two-dimensional inviscid and irrotational compressible-flow equation, i.e., the Laplace equation. Accordingly, the perturbation velocities take on no physical meaning, and, in addition, stagnation points are restricted from a solution of this type. Furthermore, Ward's slender-body theory is applicable.

The determination of the velocity potentials in the cross-flow planes is simplified by using the conformal transformation technique, for which the authors are to be commended. Results of the analysis are applied to evaluate the velocity potentials, span loadings, pressure distributions, and associated stability derivatives for several slender-tail arrangements. The rolling stability derivatives are included for the following tail shapes: (1) Cruciform composed of two mutually bisecting, normal triangular surfaces; (2) inverted T-tail; (3) rolling V-tail; (4) rolling Y-tail; and (5) cruciform tail body.

Reviewer believes that this report will be an invaluable contribution to the field. G. B. White, USA

1567. **Braun, W., Asymmetric tailplane loads due to sideslip,** *Aero. Res. Counc. Lond. curr. Pap.* 119, 29 pp., 15 figs., 1953.

A method, accurate enough for load design, is presented for estimating the stabilizer rolling moment coefficient due to slip. It includes the aerodynamics of the tail configuration as affected by relative aspect ratio and location of the fin and stabilizer surfaces, and also the dihedral, sweepback, and planform of the stabilizer. Also included are the influence of the main wing by its dihedral, sweepback, planform, fuselage-produced antisymmetric lift, and the direct fuselage effect on the lee and windward side. Finally, estimates are found for the effect of the propeller slipstream. The results are presented in increment form so that relative values of all or part of the several influences may be calculated and noted. A tolerance is suggested for the over-all estimated and measured values on a series of eight aircraft, and aircraft models tested establishes confidence in the method and the excellence of the treatment. M. G. Scherberg, USA

1568. **Garner, H. C., The evaluation of downwash at large spanwise distances from a vortex lattice,** *Aero. Res. Counc. Lond. Rep. Mem.* 2808, 8 pp., Dec. 1950, published 1953.

The results described in the title are calculated by an improved numerical method and are of importance in the solution of wing-loading problems by vortex-lattice theory, particularly for cases involving deflected flaps. J. R. Spreiter, USA

1569. **Falkner, V. M., The solution of lifting-plane problems by vortex-lattice theory,** *Aero. Res. Counc. Lond. Rep. Mem.* 2591, 30 pp., Sept. 1947, published 1953.

The Falkner method for determining surface loading is described in good detail. Much of the development is shown in seven appendixes.

The method considers that aerodynamic loading can be calcu-

lated by concentrating an equivalent vorticity sheet into a number of elemental horseshoe vortexes arranged in a lattice and computing the total downwash at selected points (control points) on the wing surface at which the tangential flow condition is satisfied. The report describes how the control points are chosen and how the equations in the unknown variables of the loading formula are formed and solved. Guidance for choosing the most suitable chordwise and spanwise spacing of the vortex lattice is indicated by a large number of solutions for the delta wing.

J. DeYoung, USA

1570. Lehrian, Doris E., A calculation of the complete downwash in three dimensions due to a rectangular vortex, *Aero. Res. Counc. Lond. Rep. Mem.* 2771, 4 pp., 15 tables, 10 figs., Mar. 1949, published 1953.

The downwash induced by a horsehoe vortex in incompressible flow has been computed at a large number of stations situated not more than two vortex spans above or below the plane of the vortex system. These results are to be used in conjunction with those given previously [AMR **7**, Rev. 248]. J. R. Spreiter, USA

1571. Lambourne, N. C., Chinneck, A., and Betts, D. B., Measurements of the aerodynamic derivatives for a horn-balanced elevator, *Aero. Res. Counc. Lond. Rep. Mem.* 2653, 15 pp., Jan. 1949, published 1953.

The report gives the results of measurements by a forced-oscillation method of the direct derivatives (aerodynamic stiffness and damping) for a horn-balanced elevator. Tests were made at low air speeds on a complete wing-fuselage-tail model at 0° and 10° incidence in a wind tunnel. Some information was obtained on the effect of mean elevator angle on the derivatives when the model was at the high incidence. Measurements were also made with trailing-edge cords and transition wires in position.

The experiments suggest that none of the above factors causes a reduction in damping, but the stiffness derivative was found to be considerably influenced by the elevator angle and by the presence of trailing-edge cords and transition wires.

In general, the measured values are numerically considerably less than those calculated by simple strip theory using two-dimensional vortex sheet theory results.

From authors' summary

1572. Lush, K. J., The loss in climb performance, relative to the optimum, arising from the use of a practical climb technique, *Aero. Res. Counc. Lond. Rep. Mem.* 2756, 12 pp., Aug. 1949, published 1953.

A practical climb technique will not in general comply with the condition for optimum climb performance and will give an inferior climb. An assessment of the loss of performance involved is, therefore, desirable.

A practical climb technique is considered which is defined by a fixed relation between equivalent air speed (or Mach number) and pressure altitude and a rough estimate made of the loss in performance involved in using such a technique with a turbine jet aircraft over a range of air temperature, engine speed, thrust, or aircraft weight. An approximate method of calculating a suitable relation is given.

If the technique for optimum climb is not fixed by compressibility effects, use of such a practical climb technique will result in a loss of performance, relative to the optimum, less than the greater of 1% and $^1/_2$ fps in rate of climb over a wide range of aircraft weight or a moderate range of air temperature, engine speed, or thrust. Approximate limits are quoted. More precise limits may be estimated for any particular aircraft.

If the technique for optimum climb is determined by compressibility effects, such a practical climb technique can give optimum performance over a wide range of weight, air temperature, and engine speed. From author's summary

1573. Jones, W. P., and Skan, Sylvia, W.; Skan, Sylvia W., Aerodynamic forces on biconvex aerofoils oscillating in a supersonic airstream; Effect of thickness on the aerodynamic forces on biconvex aerofoils oscillating in a supersonic airstream, and calculation of forces for aerofoil with flap, *Aero. Res. Counc. Lond. Rep. Mem.* 2749, 18 pp., Aug. 1951, published 1953.

The first part (by Jones and Skan) of this two-part report gives method of calculating the aerodynamic force on an oscillating airfoil, the thickness effect of which is included. A linearized perturbation theory is superimposed on a nonlinear steady isentropic flow which is considered as approximation to the second or third order of Busemann. The perturbation solution is obtained numerically by means of finite difference method, step by step. The result is restricted to the supersonic flow. Both the shock wave and boundary layer are neglected. Lift and pitching moment derivatives of a 5% thick symmetrical circular-arc airfoil are shown for Mach number 1.4, 1.5, 2.0, and different oscillating frequencies. The corresponding results of this plate theory are compared and show that thickness becomes increasingly important on aerodynamic derivatives as the thickness ratio increases. The second part (by Skan) shows similar calculations except (a) 7.5% thickness ratio and (b) a flap attached. Some given experimental evidences compare favorably with the theory. However, in the case with flap, no accuracy is claimed for the aerodynamic derivatives, as the effect of the boundary layer is not included. C.-C. Chang, USA

1574. Campbell, J. P., and McKinney, M. O., Summary of methods for calculating dynamic lateral stability and response and for estimating lateral stability derivatives, *NACA Rep.* 1098, 40 pp., 1952.

Supersedes article reviewed in AMR **4**, Rev. 4555.

1575. Bolz, R. E., Dynamic stability of a missile in rolling flight, *J. aero. Sci.* **19**, 6, 395–403, June 1952.

Equations of motion are derived for jet-powered missile with basic rotational symmetry but small asymmetries superimposed. Analysis is restricted to customary small perturbations in angles of attack, sideslip, pitch, and yaw. New features are (a) that missile is allowed to spin at arbitrarily large rate provided spin varies with velocity, and (b) that change in velocity is limited only by variation of aerodynamic coefficients. Derivation proceeds in conventional manner from Newton's third law, and dynamic stability criteria are obtained from analysis of integrated equations.

Reviewer takes exception to conclusion: "Misalignment of the fins or wings has no effect on stability." If author's equations are simplified by neglecting all forces and retaining only principal restoring moment and trim moment due to asymmetry, the solution leads directly to expected occurrence of dynamic instability at coincidence of roll and pitch periods. Reviewer holds opinion that analysis could be sharpened and clarified if complete solution to differential equations of motion were obtained by Laplace transform and if standard aeronautical nomenclature were used.

A. C. Charters, USA

1576. Klein, H., and Sedney, R., Some basic concepts for analyzing dynamic flight test data, *Douglas Aircr. Co. Rep.* SM-14511, 33 pp., Oct. 1952.

Obtaining the aerodynamic stability derivatives of an airplane

or missile from dynamic flight tests involves the determination of the coefficients of the differential equations of motion that describe the system. Authors present a method for determining these coefficients for a system having an arbitrary number of degrees of freedom. The method includes the determination of the maximum number of coefficients that can be found by means of the free-oscillation type of flight test, as well as by means of tests involving suitable forcing functions. Two numerical applications of the analysis are given. A. Gessow, USA

1577. **Lichtenstein, J. H., Experimental determination of the effect of horizontal-tail size, tail length, and vertical location on low-speed static longitudinal stability and damping in pitch of a model having 45° sweptback wing and tail surfaces,** *NACA Rep.* 1096, 22 pp., 1952.

Supersedes article reviewed in AMR **4**, Rev. 4250.

1578. **Ferrari, C., The body and ogival contour giving minimum wave drag,** *Cornell aero. Lab. Rep.* no. 55, 23 pp., Oct. 1951.

See AMR **5**, Rev. 171.

1579. **Kölle, H. H., Influence of the parameters of the propulsion system on flight efficiency** (in German), *Weltraumfahrt* no. 3, 68–75, July 1953.

To be able to design multistep rockets, author carefully discusses principal data affecting efficiency: Jet velocity, weight of propulsion system, and thrust. He shows, for instance, how to decide the number of steps and working pressure in order to make an economic, suitable design. Calculations are mainly performed for a particular project, because a common solution is hardly possible. Author shows importance of balance between different parameters in rocket design. For that purpose, the article is very helpful. Å. Silfverhielm, Sweden

1580. **Carter, A. W., and Woodward, D. R., Static properties and resistance characteristics of a family of seaplane hulls having varying length-beam ratio,** *NACA TN* 3119, 38 pp., Jan. 1954.

The principal results of an experimental investigation of the static properties of a family of hulls having length-beam ratios varying from 3 to 20 are presented as plots of trim, draft coefficient, and rolling-moment coefficient against load coefficient. The draft, trim, and upsetting moment for this related series may be obtained from these plots for wide ranges of load, center-of-gravity location, and angle of roll. Upsetting moment increased with increase in length-beam ratio, but the rate of increase was less at the higher length-beam ratios. The required tip-float displacement increased rapidly with increase in length-beam ratio from 3 to 6. Further increase in length-beam ratio caused a relatively small increase in required tip-float displacement.

Charts are presented for the determination of resistance and trimming moment for length-beam ratios of 6 and 15 of a related series of hulls. At the speed for hump resistance, the resistance was approximately the same for both length-beam ratios, but the hump resistance occurred at a higher speed for the length-beam ratio of 15 than for the length-beam ratio of 6. At the design load, the take-off time and distance decreased approximately 5% with an increase in length-beam ratio from 6 to 15.

From authors' summary by E. G. Stout, USA

1581. **Birds, H. I., Interim report on V-g records on helicopters,** *Aero. Res. Counc. Lond. Rep. Mem.* 2746, 5 pp., Mar. 1949, published 1953.

V-g records have been obtained on Hoverfly I helicopters. Some data have also been obtained on a Hoverfly II and a Sikorsky S.51. The V-g records on these aircraft were obtained mainly during test flying, which included blind flying and some general flying. It was not possible to separate the flight accelerations from the landing accelerations, but these were small except in the case of engine-off landings, which were the subject of separate tests. From author's summary

1582. **Ellis, C. W., Effects of articulated rotor dynamics on helicopter automatic control system requirements,** *Aero. Engng. Rev.* **12**, 7, 30–38, July 1953.

The effect of helicopter dynamics upon the automatic stabilization requirements is discussed. Theoretical and experimental results of both model and full-scale are presented to verify need for consideration of rotor dynamics in analytical investigations of helicopter stability and control. Transient analysis techniques of frequency measurements, using pulse-type inputs, are satisfactory when applied to helicopter dynamic stability measurements. Curves and test data presented indicate a degree of reasonableness to discussion. R. A. Young, USA

1583. **Maruo, H., Theory of the hydroplane with broad and short planing surface,** *Bull. Fac. Engng., Yokohoma Nat. Univ.* **2**, 1–14, Mar. 1953.

1584. **Jones, R., Experiments on rigid parachute models,** *Aero. Res. Counc. Lond. Rep. Mem.* 2520, 21 pp., Nov. 1943, published 1953.

The investigations were undertaken in order to study the effect of porosity on the stability of a parachute. Experiments were conducted to obtain data which could be applied in the usual way to the standard equations of motion. These data, drag, lateral force, and yawing moment can only be obtained on rigid models, and it was suggested that porosity might be simulated in a rigid model by perforating the canopy.

From author's summary

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 1539)

1585. **Watkins, C. E., Runyan, H. L., and Woolston, D. S. On the kernel function of the integral equation relating the lift and downwash distributions of oscillating finite wings in subsonic flow,** *NACA TN* 3131, 44 pp., Jan. 1954.

The kernel function is reduced to two parts, a part in which the singularities are isolated and analytically expressed and a nonsingular part which may be tabulated. The form of the kernel function for the sonic case (Mach number 1.0) is treated separately. In addition, results for the special cases of Mach number 0 (incompressible case) and frequency of 0 (steady case) are given. The reduction of the kernel function obtained for the three-dimensional case to Possio's two-dimensional case is shown.

This paper, together with Kuessner [*J. aero. Sci.* **21**, 1, Jan. 1954], represents two recent major advancements in the oscilating-finite-wing theory. Y. C. Fung, USA

1586. **Bergh, H., and Ijff, J., Application of experimental aerodynamic coefficients to flutter calculations,** *Nat. LuchtLab. Amsterdam Rap.* F.122, 6 pp., 1953.

Authors investigate theoretically the bending-torsion flutter of rectangular wings with fixed roots. Critical speeds are calculated for various positions of the elastic and inertial axes and for a range of values of relative density and wing natural frequencies. The two-dimensional aerodynamic coefficients used are based

either on (a) flat plate theory or (b) measured values for the wing section assumed. It was found that coefficients (b) gave lower or higher critical speeds than coefficients (a), depending on what wing parameters were chosen. In most cases the speeds were lower and a maximum decrease of about 20% was obtained for some wing conditions. Authors therefore suggest that coefficients (b) should be used in flutter calculations.

The effects on flutter speed of aspect ratio, changes in mode of distortion, and changes in shape of wing section are not discussed. For the wings considered, the aspect ratio and section shape are not specified. W. P. Jones, England

1587. Jones, W. P., Aerofoil oscillations at high mean incidences, *Aero. Res. Counc. Lond. Rep. Mem.* 2654, 9 pp., Apr. 1948, published 1953.

A method of calculation is suggested which makes use of the steady motion characteristics of the airfoil. A comparison between the estimated and measured values of the pitching-moment derivatives for a particular airfoil shows that the method suggested gives better agreement with experiment than the usual vortex-sheet theory. B. Smilg, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1522, 1582, 1614, 1642)

1588. Lee, J. F., Theory and design of steam and gas turbines, New York, McGraw-Hill Book Co., Inc., 1954, xiv + 502 pp. $9.

This book has been written with two stated aims: (1) To provide a textbook for the student of mechanical engineering; (2) to help the practicing engineer, whose principal experience has been with steam turbines, acquire a greater knowledge of gas turbines. Fundamentals of thermodynamics are reviewed briefly in one chapter. Cycles of the steam turbine covered are the Rankine cycle, cycle with one reheat, and regenerative cycle with a single stage of extraction. Cycles of the gas turbine are covered in greater detail; these cycles include the Brayton, Sterling, and Ericsson. Intercooling, reheating, and regenerative heat exchanges are discussed from the point of view of their use in cycles of operation of the gas turbine.

There is one chapter on elementary gas dynamics. Cases of one-dimensional gas flow discussed are: (1) Adiabatic flow with friction in a passage of constant area of cross section; (2) frictionless flow of compressible fluid with heat transfer in a passage of constant area; (3) reversible, adiabatic flow in nozzles. There is a short discussion of two-dimensional, concentric, circulatory flow and of elementary airfoil theory.

Although the energy interchanges between the fluid and rotor are discussed, the most complete treatment in the book covers the design of the flow passages of a turbine. Illustrative examples are given of the design of flow passages for a steam turbine with a single impulse stage and two rows of moving blades and for a reaction gas turbine assumed to be using air as the working fluid.

Mechanical and metallurgical aspects of turbine design are treated in one chapter, including parasitic losses, leakage, vibrations, stresses, and cooling of gas-turbine blades. Control and performance of steam turbines are treated briefly.

Theory of operation of the centrifugal compressor is discussed, and applications are given of this theory to the design of centrifugal air compressors. The axial-flow compressor is given a similar treatment.

Chemistry of combustion, equilibrium, heats of reaction, flame temperatures, and dissociation are covered; there is no rigorous treatment of combustion theory beyond a very brief statement of some of the current postulations. Heat-transfer theory, as applied to the design of regenerators for gas turbines, is reviewed.

The performance of the complete gas-turbine plant is explained in terms of the dimensionless parameters of pressure ratio and reduced flow.

At the end of most chapters, references to a more complete treatment of the chapter topics are given. Also, problems are presented which illustrate the principles covered in each chapter. In the appendix there are ten tables abstracted from "Gas tables" by Keenan and Kaye [AMR 2, Rev. 1323]. Also, there are three tables of the thermodynamic properties of water, saturated steam, and superheated steam as abridged from "Thermodynamic properties of steam" by Keenan and Keyes.

C. O. Mackey, USA

1589. Taylor, R. G., Some blade designs for an axial flow compressor stage, *J. roy. aero. Soc.* **58,** 517, 61–64, Jan. 1954.

Over-all conditions in a rotor-stator stage of an axial compressor are discussed in which (a) the static temperature rise is equal in both rotor and stator, (b) the Mach number of the resultant flow is independent of radius at the inlet to the rotor, and (c) a combination of (a) and (b). In case (a) it is found that the circumferential flow is of the forced vortex type both at inlet and outlet from the rotor. No appeal is made to cascade theory to find out if the resulting blade designs would be suitable or even practical. G. M. Lilley, England

1590. Stephenson, J. M., Efficiency and drag of an axial-flow compressor stage, *Aircr. Engng.* **25,** 292, 158–160, June 1953.

Author discusses the efficiency concepts which are frequently used in axial-flow compressor design. In particular, he discusses stage efficiency in terms of blade forces. Reliable efficiency data and methods by which to apply them are in continual demand by turbomachinery engineers and designers.

From the moment of momentum and the energy equations, stage-efficiency formulas in terms of blade forces are developed for the blade row, and these results are compounded for the complete stage. Sources of inefficiency are discussed in a general way. A convenient way to represent the efficiency of more than one blade row is proposed. A concise discussion of stage efficiency and the losses in an axial-flow compressor is presented.

Some of the results are somewhat doubtful since they are based on Eq. (4) which, in the reviewer's opinion, is questionable. This equation appears to set the stage efficiency equal to the sum of the efficiencies of its blade rows. Ordinarily that procedure would not produce satisfactory results. Toward the end of the paper there is an interesting discussion of the sources of and the order of magnitude of some of the losses suffered by an axial-flow compressor. B. F. Shattuck, USA

1591. Numachi, F., and Murai, H.; Numachi, F., and Abe, S.; Numachi, F., Murai, H., Abe, S., and Chida, I.; Numachi, F., Abe, S., and Chida, I., Cavitation tests on hydrofoil profiles suitable for arrangement in cascade (1st, 2nd, 3rd and 4th Reports), *Rep. Inst. high speed Mech., Tōhoku Univ.* **2, 3;** 1–44, 99–162, Mar. 1952, Mar. 1953.

Paper consists of four progress reports, each one dealing with one aspect of a research made to develop better blade profiles for axial-flow turbines, pumps, and ship propellers. Special attention is given to the interference effect of the adjacent blades to arrive at a "cascade-profile," namely, a profile form which could be excellent when it is arranged in a cascade, although it might not be so excellent in a single condition.

The first report gives an approximate method of computing a cascade-profile on the basis of the idea that the effect of interference on one profile due to the remaining profiles can be regarded as equivalent to the effect due to flat plates arranged in a cascade. The second report gives a more rigorous treatment of the problem and exposes an exact method of determining cascade-profiles. Profiles by first and second methods were tested in a closed water tunnel and results are published in detail.

A comparison is made in the third report by both the approximate and the exact methods mentioned above of profiles having the same pressure distribution on the pressure side but having falling, level, or rising pressure characteristics on the vacuum side.

Based upon results given in the third report, the fourth report deals with three profiles whose pressure distribution shows a gradual rise toward the tail. Results of all the cavitation tests made are given in graphical form, stating the conditions under which danger of erosion due to cavitation and strong vibrations occurs.

Authors claim that the new profiles show better characteristics than the ones usually used, especially when cavitation is involved. A. Leclerc, Canada

1592. **Bridle, E. A., Some high-speed tests on turbine cascades,** *Aero. Res. Counc. Lond. Rep. Mem.* 2697, 14 pp., Feb. 1949, published 1953.

High-speed wind-tunnel tests on seven cascades of turbine blades are described, the blades having conventional sections including both reaction and impulse designs. The two-dimensional performance over wide ranges of incidence at Mach numbers up to 1.0 is discussed, special importance being attached to the effects of compressibility.

It is shown that the effect of increasing the degree of reaction is to reduce the total-head loss and to increase the unstalled incidence range. High Mach numbers alone are not found to cause a catastrophic increase in loss with these particular blade designs, while the $\cos^{-1}$ throat/pitch rule is found to be approximately true only at high Mach numbers. From author's summary

1593. **Persh, J., and Bailey, B. M., A method for estimating the effect of turbulent velocity fluctuations in the boundary layer on diffuser total-pressure-loss measurements,** *NACA TN* 3124, 16 pp., Jan. 1954.

The method, based on several assumptions, presents the case of a conical diffuser with incompressible flow. When longitudinal velocity fluctuations are small, the total-pressure-loss coefficient calculated by this method is in agreement with experiment.

From authors' summary by A. Petroff, USA

1594. **Lukasiewicz, J., Diffusers for supersonic wind tunnels,** *J. aero. Sci.* **20,** 9, 617–626, Sept. 1953.

Paper reviews published experimental data for diffusers with entry Mach numbers M up to 10. It was found that: (1) Compressibility effects are negligible in diffusers for $M < 0.9$ when performance is expressed as ratio of actual to theoretical pressure rise. (2) Shock compression is more efficient in constant area than in divergent ducts and usually requires appreciable duct length for completion. (3) Pressure recovery of diffusers without contraction is improved by use of a long throat at entry, but is always smaller than the theoretical normal shock recovery. (4) For $M < 4$, maximum or starting contraction of constant geometry diffusers is closely predicted by simple theory, and better than normal shock pressure recoveries are achieved. (5) With variable contraction diffusers, pressure recoveries of as much as twice the normal shock recovery are obtainable at hypersonic Mach numbers. In general, optimum diffuser contraction angles increase with entry Mach number increasing.

From author's summary by N. H. Johannesen, England

1595. **Nicholson, H. M., and Radcliffe, A., Pressure fluctuations in a jet engine,** *Brit. J. appl. Phys.* **4,** 12, 359–365, Dec. 1953.

Pressure fluctuations have been recorded at various points in the ducting of a jet engine. The recordings were made under a variety of steady running and accelerating conditions with a standard engine and with engines adapted for two different afterburning systems. This report includes a brief description of the recording equipment and its method of use, a summary of the test conditions, a description and analysis of the pressure records obtained, and a discussion of the test results. In the discussion an attempt is made to explain the observed pressure fluctuations, and their significance in relation to practical engine operation and combustion-system design is stressed.

From authors' summary

1596. **Klein, H., Small scale tests on jet engine pebble aspiration,** *Douglas Aircr. Co. Rep.* SM-14885, 22 pp., Aug. 1953.

1597. **Bauer, L., New laboratory for three-dimensional guided missile simulation,** Proc. Western Computer Conf., Los Angeles, Calif., Feb. 4–6, 1953, 187–195.

1598. **Ferraro Bologna, G., The influence of the temperature on the starting of the high-speed diesel motors** (in Italian), *Monogr. Lab. Aero. Politecn. Torino* no. 306, 5 pp., 1953.

Short discussion of problems connected with the starting of diesel engines at low temperatures and results of preliminary experiments, carried out in the aeronautics laboratory of the Turin Polytechnic Institute, on an automobile engine of 4.58-liters (709 cu in.) volume. The principal results of earlier work of Triebnigg and Knudsen are mentioned and the experimental plant is briefly described. Low temperature-starting at air and oil temperatures of about -18 C (4 F) was effectuated by using a powerful 24-volt storage battery, and a preliminary diagram giving the total number of revolutions during the starting process as a function of the temperature was established. Further experiments will complete these results and will provide a parameter as an appropriate measure for the case of the starting process, or, at least, will help to find a better method for the design of the starting apparatus. A. Kuhelj, Yugoslavia

1599. **Lype, E. F., The effect of leakage on the performance of reciprocating gas-operated mechanisms,** Proc. First U. S. nat. Congr. appl. Mech., June 1951: J. W. Edwards, Ann Arbor, Mich., 957–962, 1952.

The motion of a free piston in a gas-filled cylinder is investigated for the case that gas leaks out past the piston. Exact solutions are given for the nonlinear differential equations representing the travel-time law and the work of expansion of the moving piston. An example taken from current practice shows that the effect of leakage on the power output can be considerable.

From author's summary by H. J. Stoever, USA

1600. **Ziebart, E., Investigations on a Föttinger drive** (in German), *ZVDI* **95,** 30, 1027–1036, Oct. 1953.

The results of a theoretical calculation of the Föttinger drive are compared with experiments. The efficiency shows a very good agreement, the moments also agree in general, but under some conditions there are greater differences. These result from

differences of the real flow from the flow assumed in the theory. Especially when the output of the pump is zero, there is an exchange of momentum by fluid parts going in the one and in the other direction. Other differences result from the extreme direction of the flow to the blades. This is shown by photographs made in a water channel. Under some conditions the revolutions were unstable. A. Betz, Germany

Flow and Flight Test Techniques

(See also Revs. 1533, 1549, 1594, 1650, 1664)

1601. van den Bouwhuysen, J. N. A., Starting loads in supersonic wind tunnels, *Aero. Engng. Rev.* **13,** 1, 50–51, Jan. 1954.

A technique of wind-tunnel operation is discussed which results in a considerable reduction of the shock loads on sting-mounted models during the starting and stopping periods of the wind tunnel. The technique consists of a two-step opening and closing of the upstream valve located between the reservoir and the test section. Partial opening of the valve during the periods of unsteady flow reduces the density of the air in the test section and consequently the shock loads on the model.

It is shown that the technique is most effective at higher Mach numbers where the shock loads are normally large. The reduction of the loads at lower Mach numbers is limited by the fact that the wind tunnel cannot be started if the upstream valve opening is restricted below a critical value. It is also shown that a compromise with respect to running time may be necessary to obtain the benefit of the valve-opening technique during the stopping period of the wind tunnel. From author's summary

1602. Murphy, J. S., Evidences of an inherent error in measurement of total-head pressure at supersonic speeds, *Aero. Engng. Rev.* **12,** 11, 47–51, Nov. 1953.

Author assumes true Mach number can be calculated from static and total-pressure measurements at test section of supersonic wind tunnel of intermittent type. On this basis he shows from test results that small loss of stagnation pressure occurs during expansion, which cannot be completely accounted for by known sources of loss. After eliminating other factors, he arrives at conclusion that inherent error probably exists in total-pressure measurements (made with blunt-nosed circular tube), and suggests, as possible cause to be further investigated, the existence of complex flow field (such as reverse or rotational flow) around or inside tip of probe, presumably resulting from probe shock wave. Complete details of calculation are not given, and reviewer questions adequacy of assumption; but principal purpose of paper is to stimulate interest in refinement of supersonic testing techniques. C. W. Smith, USA

1603. Savitt, J., and Stresau, R. H. F., Velocity attenuation of explosive-produced air shocks, *J. appl. Phys.* **25,** 1, 89–91, Jan. 1954.

A method for measuring the velocities of explosive-produced air shocks using an electrical ionization probing system is described. The results of such measurements indicate that, under varying conditions of confinement of explosive and air shock, the reciprocal of the air-shock velocity varies linearly with the distance to the charge surface. From authors' summary

1604. Somerville, T. V., Duddy, R. R., and Buxton, G. H. L., Tests on a Whirlwind aircraft in the Royal Aircraft Establishment 24-ft wind tunnel, *Aero. Res. Counc. Lond. Rep. Mem.* 2603, 17 pp., June 1940, published 1953.

1605. Gregory, N., Walker, W. S., and Devereux, A. N., Wind-tunnel tests on the 30 per cent symmetrical Griffith aerofoil with distributed suction over the nose, *Aero. Res. Counc. Lond. Rep. Mem.* 2647, 14 pp., June 1948, published 1953.

Report describes tests carried out on the 30% Griffith symmetrical airfoil with continuous suction applied through a porous capping fitted over the front 15% of the upper surface. Throughout the range of incidence covered in the experiments, distributed suction was found to decrease the slot suction necessary to prevent separation, especially when the distributed suction caused rearward movement of the transition position.

The profile drag of the airfoil was measured and estimates were made of the equivalent drag coefficients for the work done by the suction pumps. Assuming no losses additional to those in the boundary layer, it was found that the effect of distributed suction was to reduce slightly the over-all drag of the airfoil.

Measurements of the velocity within the boundary layer were made at various chordwise positions on the porous surface; the profiles recorded were very close to the theoretical. Distributed suction was able to delay transition when this would otherwise be precipitated by a ridge on the surface, or by adverse pressure gradients, but a turbulent boundary layer remained turbulent when suction was applied. The characteristic spread of turbulent flow in the wake of a small particle on the surface was much reduced by distributed suction; under favorable conditions, the wake was entirely eliminated. From authors' summary

1606. Evans, J. Y. G., Corrections to velocity for wall constraint in any 10 × 7 rectangular subsonic wind tunnel, *Aero. Res. Counc. Lond. Rep. Mem.* 2662, 42 pp., Apr. 1949, published 1953.

The validity and accuracy of methods of determining corrections to the measured velocity in a wind tunnel to compensate for the constraining effect of the walls are reviewed, following recent experimental evidence from the RAE 10 × 7-ft subsonic wind tunnel. It is concluded that such corrections, commonly known as blockage corrections, can be successfully applied at Mach numbers up to 0.96, but some modifications are necessary to the formulas at present in use. The more important of these are: (1) The compressibility factor should be based on the corrected Mach number of the stream. (2) The ratio of "solid" blockage (i.e., the blockage due to model excluding wake) to the peak wall-velocity increment is not constant but depends on the length of the model and the Mach number of the stream. (3) The calculated solid blockage of a wing must be increased to allow for the presence of local supersonic flow. For wings of usual planform, this may be done by an empirical factor which is a function of the rise in drag coefficient. (4) Addition of corner fillets to the tunnel gives rise to a larger percentage increase of the solid blockage than of the wall-velocity increments.

Formulas for the calculation of the longitudinal distribution of blockage increment due to any model, necessary to check the validity of the method in particular cases, are presented in a form which, it is hoped, will facilitate their use in any 10 × 7 wind tunnel. Formulas for the corresponding wall-velocity increments, used to check the accuracy of the method by comparison with measured wall pressures, are also given.

From author's summary

1607. Squire, H. B., Fail, R. A., and Eyre, R. C. W., Wind-tunnel tests on a 12-ft diameter helicopter rotor, *Aero. Res. Counc. Lond. Rep. Mem.* 2695, 19 pp., Apr. 1949, published 1953.

Measurements of the thrust, torque, and flapping angle for a 12-ft diam rotor over a range of blade angle, shaft inclination, and

tip-speed ratio have been made to give information on the validity of the standard rotor theory and of the effect of stalling on the retreating blade. Good agreement with the theory was obtained over the normal operating range, using airfoil characteristics determined from the measurements in the static thrust condition. Stalling was found to be progressive in character, showing first by an increase in torque and flapping angle and later by a fall in thrust, as compared with the calculated values.

From authors' summary

1608. **Gregory, N., Pankhurst, R. C., and Walker, W. S., Wind-tunnel tests on the prevention of boundary-layer separation by distributed suction at the rear of a thick aerofoil (NPL 153),** *Aero. Res. Counc. Lond. Rep. Mem.* 2788, 7 pp., Oct. 1950, published 1953.

Tests of a preliminary nature have been carried out on a 33% thick symmetrical airfoil (NPL 153) with suction through a porous surface from 0.80 chord to the trailing edge, which was rounded and fitted with a Thwaites flap. The distributed suction was found to prevent separation and to reduce the wake drag to zero. The over-all effective drag (including an allowance for the power required for the suction) was reduced slightly, but still remains fairly high. No hysteresis was observed in the change of drag with suction quantity.

The flap was essential to stabilize the flow; without it, the flow with suction was unsteady and the wake drag was appreciable. When the flap was deflected 20° there was no increase in the suction quantity required to prevent separation.

From authors' summary

1609. **Anonymous, Specifications for AGARD wind-tunnel calibration models** (in French and English), *AGARD Memo.* AG4/M3, Rome AGARD Conf., Dec. 12–19, 1952, 4 pp.

1610. **Ferri, A., and Nucci, L. M., Preliminary investigation of a new type of supersonic inlet,** *NACA Rep.* 1104, 19 pp., 1952.

Supersedes article reviewed in AMR **4,** Rev. 4232.

1611. **Habel, L. W., Henderson, J. H., and Miller, M. F., The Langley annular transonic tunnel,** *NACA Rep.* 1106, 10 pp., 1952.

The development of the Langley annular transonic tunnel, a facility in which test Mach numbers from 0.6 to slightly over 1.0 are achieved by rotating the test model in an annular passage between two concentric cylinders, is described.

Data obtained for two-dimensional airfoil models in the Langley annular transonic tunnel at subsonic and sonic speeds are shown to be in reasonable agreement with experimental data from other sources and with theory when comparisons are made for nonlifting conditions or for equal normal-force coefficients rather than for equal angles of attack. The trends of pressure distributions obtained from measurements in the Langley annular transonic tunnel are consistent with distributions calculated for Prandtl-Meyer flow.

From authors' summary

1612. **Rind, E., A photographic method for determining vertical velocities of aircraft immediately prior to landing,** *NACA TN* 3050, 23 pp., Jan. 1954.

Paper describes method employing a 40-in. lens for obtaining statistical data on vertical velocities of aircraft just before landing contact. It requires no installation on the aircraft or interference with airport operation and employs relatively simple data reduction. Vertical velocities are obtained within a probable maximum error of ±0.31 fps.

H. Luskin, USA

1613. **Ducoffe, A. L., Pressure response in supersonic wind-tunnel pressure instrumentation,** *J. appl. Phys.* **24,** 11, 1343–1354, Nov. 1953.

The response time of a system consisting of a capillary tubing and pressure capsule is calculated numerically for three specific cases using step-by-step integration. Fully developed Hagen-Poiseuille flow is assumed in the tube. The equation of continuity is then used to find a quasi-steady equation for the motion in the tube, assuming isothermal flow. Effect of the volume of the pressure capsule is considered in the boundary condition. Thus density changes but not momentum changes of the fluid in the tube are included. An instantaneous pressure difference is applied to the system and the response time then calculated for three specific cases. The results are compared with experiment and good agreement is obtained. The influence of the various parameters is discussed in detail. An appendix contains a correction to the theory if slip flow should occur in the tube.

P. F. Maeder, USA

1614. **Dunsby, J. A., Schlieren tests on some conventional turbine cascades,** *Aero. Res. Counc. Lond. Mem.* 2728, 14 pp., Sept. 1949, published 1953.

Schlieren tests on a series of conventional turbine cascades have shown that the variations in performance at high speed can be accounted for by shock-wave and boundary-layer interaction. The rise in loss coefficient sometimes encountered at outlet Mach numbers of 0.6 to 0.8 is shown to be due to the formation of a shock series on the upper surface of the blade, the subsequent fall in loss coefficient and increase in deflection as the outlet Mach number rises to unity being caused by the formation of a shock system at outlet which forces the separated part of the boundary layer back onto the blade surface. It is shown that a shock series may form on a boundary layer which is apparently turbulent. This has not been observed before.

From author's summary

1615. **Laurence, J. C., and Landes, L. G., Applications of the constant temperature hot-wire anemometer to the study of transient air flow phenomena,** *Instruments* **26,** 12, 1890–1894, Dec. 1953.

Authors discuss principles of operation of the constant-temperature hot-wire anemometer and applications to the following phenomena: Vortex shedding from flame holders, compressor surge and rotating stall, wake surveys of compressor and turbine blades, spectrum, intensity, and scale of turbulence.

L. M. Grossman, USA

1616. **Maruo, H., and Matsubara, S., Application of the hot wire measurement to water current,** *Bull. Fac. Engng., Yokohama Nat. Univ.* **2,** 15–21, Mar. 1953.

Authors describe experiments with a simple constant-temperature hot-wire bridge for measuring steady-flow velocities in water. Although some of the difficulties of measurement are indicated, they are not sufficiently described. From the reviewer's experiments [see AMR **4,** Rev. 1685] it was found that careful cleaning of the wire prior to each measurement is a prerequisite for obtaining the type of consistency claimed in this paper.

M. S. Macovsky, USA

1617. **Weinig, F. S., Some properties of foam and the possible use of foam for model test especially in hypersonic range,** Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 515–527, 1953.

1618. **Salter, C., Multiple-jet white-smoke generators,** *Aero. Res. Counc. Lond. Rep. Mem.* 2657, 18 pp., Mar. 1950, published 1953.

Descriptions are given of equipment devised for the generation of fairly large quantities of an optically dense white smoke, and special attention has been paid to the need for delivering this through long ducts or against an appreciable back pressure.

The smoke consists of very small particles of condensed paraffin vapor and is obtained by directing jets of cool air onto high-speed jets of the vapor issuing from very small orifices. The optimum outputs are about 6 cu ft (170 liters) and 8 cu ft (230 liters) per min from no. 1 and no. 2 generators, respectively, but considerably larger quantities can be delivered with a slight loss of opacity. Under normal operating conditions the rate of use of paraffin is rather less than 2 cu in. (33 cc) (no. 1) and 3 cu in. (49 cc) (no. 2) per min. From author's summary

Thermodynamics

(See also Revs. 1628, 1643)

1619. **La Mer, V. K., Some current misinterpretations of N. L. Sadi Carnot's memoir and cycle,** *Amer. J. Phys.* 22, 1, 20–27, Jan. 1954.

Carnot has often been accused of having laid the basis for the second law on a proof which violated the first law. La Mer shows how, if subsequent Carnot memoirs are examined and if the words "feu," "chaleur," and "calorique" are translated as "heat," "heat," and "entropy," respectively, the criticisms and "corrections" by Clapeyron, Callendar, Kelvin, Clausius, and later authors become superfluous. It is clear from publications by Carnot subsequent to his "Réflexions" that the modern views of heat, motion, and availability were held by Carnot.

M. Tribus, USA

1620. **Einbinder, H., The application of Jacobians to statistical thermodynamics,** *J. chem. Phys.* 21, 12, 2134–2142, Dec. 1953.

Shaw's Jacobian method for calculating thermodynamic derivatives is extended so that any partial second derivative can be expressed in terms of two sets of reference derivatives based on the independent variables (V, T) and (P, T), respectively. A simplified and enlarged table of second-order Jacobians is given in terms of these reference sets. Methods are developed for obtaining the reference J's explicitly in the cases of greatest importance in statistical thermodynamics, i.e., from A, E, the partition function, and the caloric equation $PV = sE$, permitting any first or second partial derivative to be found as an explicit function of (V, T).

Numerous applications are shown.

From author's summary by M. Tribus, USA

1621. **Allis, W. P., and Herlin, M. A., Thermodynamics and statistical mechanics,** New York, McGraw-Hill Book Co., Inc., 1952, viii + 239 pp. $6.

This text provides a compact integration of current practices and principles in the two subject areas. It is not intended to serve as a basic treatise, although adequate references are given for anyone wishing to examine details of the theory. The first six chapters cover the physical principles of thermodynamics in the classical manner. The organization of the material is patterned on the treatment of Zemansky ["Heat and thermodynamics"], as acknowledged by the author. The last five chapters develop the elements of statistical mechanics with constant reference to the thermodynamic introduction. The statistical treatment of entropy is developed initially according to the Boltzman distribution. Subsequent chapters discuss quantum statistics and degenerate gases. In general, this provides a useful introduction and orientation, particularly for those who are concerned with applications rather than intensive work in this field.

N. A. Hall, USA

1622. **Kluitenberg, G. A., De Groot, S. R., and Mazur, P., Relativistic thermodynamics of irreversible processes I,** *Physica* 19, 8, 689–704, Aug. 1953.

Paper extends Eckert's relativistic theory to a mixture with an arbitrary number of chemical components. Author assumes special relativity, rest mass is conserved, and the medium is isotropic. Phenomena of diffusion, heat conduction, viscous flow, and chemical reactions with their cross effects are considered. It is shown that the Onsager relations are Lorentz invariant and a new cross effect between diffusion and heat conduction is obtained. Most of the paper is devoted to the formulation of the basic conservation laws and the second law in tensor invariant form.

R. E. Street, USA

1623. **Green, H. S., Molecular theory of fluids,** New York, Interscience Publishers, Inc., 1952, viii + 264 pp. $5.75.

The book contains nine chapters and about 90 references. In the first chapter, the physical properties of fluids are discussed. Fluids, gases, condensation, and fluids in motion are described from the microscopic point of view. The concepts of quantum theory are introduced. Finally, the mathematical technique and notation are given. The vector analysis employed is the same as that used by Chapman and Cowling.

Chap. 2 treats the statistics of molecular motion. Probability and averages, fluid density, distribution of molecular velocities, molecular mechanics of fluids, statistical thermodynamics, statistical mechanics of fluids, and the theory of partition are treated. In the third chapter, the structure of fluids at rest is discussed. Scattering of x rays by fluids, optical scattering and density fluctuations, the structure of fluids, distribution function in general, properties of the entropy of fluids, the radial distribution function, and the intermolecular forces are covered. Chap. 4 is concerned with the condensation and the liquid state. The nature of condensation, the cluster integrals, the virial series, the theory of condensation and approximate methods of evaluating the partition functions, as well as the solid state, the theory of freezing, and the cell model of liquids are discussed. Chap. 5 treats the structure of fluids in motion. General considerations are given first, then the molecular distribution, the theory of flow, viscosity, and thermal conduction (the dissipation processes), the theory of nonuniform fluids, the theory of friction constant and its application to nonuniform fluids, and the motion of molecular clusters are discussed. The sixth chapter deals with complex fluids, fluid mixtures, and the theory of diffusion.

Chap. 7 treats elasticity, surface tension, the Brownian motion, the second virial coefficient, gravity and boundary forces, and the dielectric constant. In chap. 8 the kinetic theory of fluids, Boltzmann's equation, corrections to it, its solution, and also the problems of viscosity and thermal conduction are treated. The ninth chapter contains the quantum theory of fluids. The general principles, a comparison with the classical theory, the equilibrium in the quantum theory, quantum statistics, and the quantum theory of flow are given.

The book is an ambitious one, since the material it contains is far too great to be treated in all its details within 260 pages; however, it is very clearly written and will serve as an excellent introduction to this complex field. It is a carefully executed book and

should be very useful as a textbook treating the molecular theory of fluids. The author is to be congratulated for his work.

T. P. Torda, USA

1624. **Brückner, H., Gas tables. Including physical, thermodynamic, and other properties related to combustion of gases and fuels [Gastafeln],** München, R. Oldenbourg, 1952, 222 pp.

This volume contains 215 pages of data, mainly in tabular form, of various properties of industrially important fuels and their products of combustion. The subject matter is divided into five parts. Part I presents data for technical fuels in gaseous, liquid, and solid form, and their products of combustion. Part II presents some physical properties of these fuels and their products, such as density, solubility, viscosity, etc. Part III presents some thermodynamic properties, such as saturation pressure, vapor partial pressures in saturated mixtures, van der Waals constants, critical constants, dissociation constants, specific heats, etc. Part IV presents properties related to combustion processes, such as heat of combustion, theoretical air requirements, adiabatic combustion temperatures, kindling temperatures, etc. Part V presents a few tables to aid in general computations, such as tables on units, conversion factors, etc.

The objective of the author seems to be to provide some data on all the substances and properties that might be of interest to the specialist in combustion. The data for any one substance are generally brief rather than convenient and they are usually taken from other handbooks. The index is less detailed than is the custom in similar American books.

J. H. Keenan and J. Kaye, USA

1625. **Mason, E. A., and Rice, W. E., The intermolecular potentials for some simple non-polar molecules,** Univ. Wisc. ONR-6, 34 pp., Nov. 1953.

The three-parameter exp-six intermolecular potential has been shown to be able to predict, with a single set of potential parameters, the properties of gases composed of spherical molecules with fair accuracy. For the gases considered here, however, the simpler two-parameter Lennard-Jones (12-6) potential is scarcely inferior (in contrast to the case of helium and hydrogen). For gases whose molecules deviate appreciably from spherical symmetry, a single set of potential parameters is not able to reproduce all the measured properties. Since the form of the exp-six potential is physically realistic and quite flexible, such behavior would seem to indicate that the assumptions of central intermolecular forces and elastic intermolecular collisions made in the basic theory are inadequate to describe the behavior of most real gases.

From authors' summary

1626. **Kostryukova, M. O., and Strelkov, P. G., Specific heat of solid oxygen below 4° K** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **90,** 4, 525–528, June 1953.

Measurements were carried out with the new type of calorimeter in ranges 4.2–2.2 K and 2.5–1.2 K. Results plotted as C/T against T^2 fall on a straight line passing through origin. Specific heat of solid oxygen can be described by cubic law with characteristic Debye temperature $\theta_D = 126$. The above plot lies below the values measured by Clusius [*Z. phys. Chem.* **3,** 41, 1929] and Giauque and Johnston [*J. Amer. chem. Soc.* **51,** 2300, 1929]. Validity of equation deduced by Landau and Pomeranchuk (no ref.), connecting magnetic susceptibility, coefficient of linear term in expression for specific heat, and several universal physical constants supposed to be valid for dielectric paramagnetic bodies is not confirmed. Hypotheses aimed at an explanation of failure of this equation for solid oxygen are discussed. There is no indication of the temperature scale used, the accuracy of measurement, or of the experimental results.

J. Kestin, USA

1627. **Hauffe, K., The mechanism of oxidation of metals and alloys at high temperatures,** *Progress in Metal Physics* **4,** 71–104, 1953; New York, Interscience Publishers.

This chapter concerns the reaction between a solid metal and oxygen or an oxidizing gas. This reaction is complex because the reaction product separates the reactants. Therefore, a knowledge of how atoms, ions, and electrons diffuse through the oxide layers is required. Author provides a theoretical point of view to the problem of oxidation of metals and alloys and critically reviews available data on this topic.

Motion of ions in ionic crystals is discussed in terms of lattice defects according to Frenkel and Schottky. The general formula for high-temperature oxidation developed by Wagner is derived. Many gas-metal systems are considered in the light of the Wagner theory. Included are the zinc-oxygen, copper-oxygen, iron-sulphur systems. Consideration is given to oxidation of alloys and the influence of the additions of small amounts of a foreign metal. These are treated by the application of the law of mass action to ionic and electronic lattice defects in impure crystals.

Systems discussed in this light include bromidization of silver in the presence of small amounts of cadmium, lead, zinc, and the chlorides of lead and cadmium. The influence of small amounts of aluminum, lithium, and thallium on the rate of oxidation of zinc is considered. The oxidation of titanium in the presence of tungsten is discussed, as is the oxidation of impure nickel and silver. The oxidation of iron at various temperatures and pressures is discussed in detail.

E. R. Funk, USA

Heat and Mass Transfer

(See also Revs. 1412, 1494, 1504, 1552)

1628. **Keyes, F. G., Thermal conductivity of gases,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-58, 8 pp.

Equipment is described for the measurement of thermal conductivity of gases in low and high temperature ranges, from 0 to −190 C and from 400 to 900 C, respectively. Equipment for the range from 0 to 400 C has been described previously [F. G. Keyes and D. J. Sandell, Jr., AMR **4,** Rev. 2713]. New experimental results are given for the temperature coefficient of emf of copper-constantan thermocouples in the low temperature range.

New measurements of the thermal conductivity of the gases neon, argon, hydrogen, nitrous oxide, methane, ammonia, ethane, ethylene, ethyl chloride, Freon 12, and Freon 114 are reported. These measurements cover a sufficient range of pressure to allow formal treatment of the pressure effect for all the gases listed, except neon.

Comprehensive literature reviews and formulations are given for both viscosity and thermal conductivity of the rare gases.

This paper is a valuable addition to an already impressive list of publications in this field by the author and co-workers.

S. Gratch, USA

1629. **Weinig, F. S., Solutions of heat-conduction problem with the aid of the inverse method,** *J. appl. Mech.* **20,** 4, 489–496, Dec. 1953.

A differential equation is derived for the boundary on which a solution of the Laplace equation satisfies the boundary condition $T + r(\partial T/\partial M) = \text{const}$. Interpreting the problem as the temperature distribution in a solid, author takes simple solutions such as $T = X$ and obtains the temperature distribution in fins.

W. Squire, USA

1630. Voskrensenskiĭ, K. D., Estimation of thermal conditions in shafts (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **88,** 1, 61–62, Jan. 1953.

Paper contains, in reviewer's opinion, a mistake which makes author's conclusions quite incorrect.

Transformation (2) reduces the problem (1) not at all to the Riemannian case (3) about heating the semi-infinite solid. Even the fundamental equation

$$\partial t/\partial \tau = a/r\ \partial/\partial r(r\partial t/\partial r)$$

changes into the following complicated relation: $(r_0^2 e^{4x/r_0} - 4aT)\cdot\partial t/\partial T = a(r_0^2\partial^2 t/\partial x^2 + 4r_0 T\partial^2 t/\partial x\partial T + 4T^2\partial^2 t/\partial T^2)$.

V. Vodička, Czechoslovakia

1631. Hales, K. C., and Farmer, J. D., The insulation of a refrigerated cargo liner, *Trans. Inst. mar. Engrs.* **65,** 8, 189–199, Aug. 1953.

Authors review the various ways in which heat enters the cargo spaces of a refrigerated ship. This is discussed in relation to the total demand on the refrigerating machinery. The effect of various depths of insulation on the ship as a carrier of refrigerated cargo is examined. In particular, the interdependence of the power of the fans used to circulate air and the standard of insulation is illustrated for a particular example. The effect of insulation and fan power on cargo capacity and deadweight is shown. There is an optimum depth of insulation which will give a minimum of capacity lost to insulation and air ducts and a minimal penalty on deadweight.

The necessity, in some cases, to use insulation as a means of minimizing condensation may mean a heavier insulation in places than would be required on grounds of temperature control. The effect on heat leakage of position in the ship and type of space is shown. The disposition of insulation as between overheading and deck in a locker is discussed. While no suitable insulating material of lower thermal conductivity than those in common use is at present available, the possible savings in capacity, should one become available, are indicated.

The calculated figures for heat leakage are minimal. In practice, margins for deficiencies in construction of insulation and performance of refrigerating machinery have to be allowed. The most common causes of excessive heat leakage are by exchange of air between inside and outside of the space and by air movement through the body of the insulation.

Methods of measuring the performance of the refrigerating equipment and insulation are discussed and results of measurements on a number of ships are quoted. These suggest that, in some cases, heat leakage can be far in excess of any estimate, but that in some ships, at least, agreement between measured and estimated heat leakage is reasonably good.

From authors' summary

1632. Kapadnis, D. G., The effect of fluid motion on heat transmission. Part I—Vertical cylinders, *Indian J. Phys.* **27,** 2, 77–89, Feb. 1953.

Author summarizes his experimental results with air striking a heated cylinder, described previously in a paper by himself and D. V. Gogate [title source, **26,** 171, 1952] by the formula

$$Nu = 0.56(Re)^{0.517}$$

(Nu is Nusselt number, Re is Reynolds number), the Reynolds number varying between 10^3 and 10^5. The effect of a continuous increase of the exponent of Re with Re, found by R. Hilpert [*Forsch. Geb. Ing.-Wes.* **4,** 215, 1933] is thus not confirmed. An explanation of this discrepancy, however, is not given. In addition, some results with cylinders variously inclined to the air stream, as well as cylinders with a cloth covering, are communicated.

A. von Baranoff, France

1633. Monaghan, R. J., and Cooke, J. R., The measurement of heat transfer and skin friction at supersonic speeds. Part III, *Aero. Res. Counc. Lond. curr. Pap.* 139, 63 pp., Dec. 1951, published 1953.

Continuation of investigation reviewed in AMR **5,** Revs. 1813 and 2930. Mean value of temperature recovery factor was 0.906 for turbulent boundary layer with improved testing equipment, and over-all heat-transfer measurements from plate to stream agreed well with Colburn equation based on wall properties. Heat transfer into boundary layer reduced transition Reynolds number, changed the exponent of turbulent velocity profile, and increased displacement thickness, but no decrease in skin friction below value for zero heat transfer was found. For no heat transfer, boundary-layer temperature distribution varied as square of velocity distribution; for specified free-stream temperature, difference between temperature distributions with and without heat transfer showed an approximately linear variation with velocity. Description is presented of traversing pitot-thermocouple for surveying impact pressure and temperature through boundary layers and of impact pressure surveys along plate for determining boundary-layer transition zone.

W. F. Davis, USA

1634. Monaghan, R. J., and Cooke, J. R., The measurement of heat transfer and skin friction at supersonic speeds, Part IV, *Aero. Res. Counc. Lond. curr. Pap.* 140, 42 pp., June 1952, published 1953.

Final report on series of tests at supersonic speeds. In general, results confirm those obtained at the lower Mach number. Conclusions resulting from whole investigation are summarized.

Reviewer believes that extraneous influences, such as leading-edge effects, cross contamination, and wind-tunnel turbulence, have not been investigated sufficiently and that the conclusions from these tests should be critically compared with those of other investigators.

W. F. Davis, USA

1635. Eber, G. R., Some aspects of supersonic heat transfer, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 161–191, 1953.

Author presents an abbreviated review of the state of the art of calculating and measuring heat transfer to bodies in supersonic flow. Dearth of data relating to turbulent boundary layers at high Reynolds and Mach numbers is stressed. Several misstatements are evident in section dealing with rarefied gases, notably the explanation given for the high recovery factors calculated and measured. The correct explanation is given in *NACA TR* 1093. The subject of transition is not discussed nor is transpiration cooling mentioned. A bibliography of 37 references is included.

J. R. Stalder, USA

1636. Davies, F. V., and Monaghan, R. J., The determination of skin temperature attained in high speed flight, *Aero. Res. Counc. Lond. curr. Pap.* 123, 32 pp., 8 tables, 18 figs., Feb. 1952, published 1953.

This interesting paper pertains to calculations of skin temperatures on high-speed missiles and illustrates the conditions under which aerodynamic heating becomes significant. Speeds considered range from 0 to 4000 fps, and altitudes from 0 to 100,000 ft in the standard atmosphere. Effects of boundary-layer flow and solar radiation are included. A simple rule for estimating the stagnation temperature rise in degrees centrigrade is $(V_{mph}/100)^2$.

M. J. Thompson, USA

1637. **Schuh, H., Aerodynamic heating on yawed infinite wings and on bodies of arbitrary shape,** *Roy. Inst. Technol., Div. Aero. TN* 35, 12 pp., 1953.

A theoretical study of recovery factors for three-dimensional boundary layers for Prandtl number 0.7. Values for laminar flow on yawed wedges with zero heat transfer and Hartree velocity profiles are almost independent of pressure gradient and nearly equal to that of an unyawed flat plate at zero incidence.

H. L. Dryden, USA

1638. **Pohle, F. V., and Oliver, H., Temperature distribution and thermal stresses in a model of a supersonic wing,** *J. aero. Sci.* 21, 8, 8–16, Jan. 1954.

The transient temperature distribution and the thermal stresses in an idealized wing structure considered by Hoff and Torda [AMR **5,** Rev. 412] are determined. Only the effects of aerodynamic heating and of heat conduction are included; radiation and convection effects are neglected. The present work differs from that of reference cited above in that the conduction from the cap to the web is considered when the temperature of the cap is calculated and the spar-cap temperature is assumed to be a function of both space and time. Graphs of temperature and thermal stress distributions are presented, and the results are compared with those of the cited reference.

From authors' summary by T. P. Torda, USA

1639. **Eckert, E. R. G., and Livingood, J. N. B., Method for calculation of laminar heat transfer in air flow around cylinders of arbitrary cross section (including large temperature differences and transpiration cooling),** *NACA Rep.* 1118, 29 pp., 1953.

Supersedes article reviewed in AMR **6,** Rev. 1007.

1640. **Saunders, O. A., and Calder, P. H., Heat transfer in a nozzle at supersonic speeds,** *Instn. mech. Engrs. Proc.* (*B*) **1B,** 6, 232–237, 1952.

See AMR **6,** Rev. 1671.

1641. **Bland, D. R., Mathematical theory of the flow of a gas in a porous solid and of the associated temperature distributions,** *Proc. roy. Soc. Lond.* (*A*) **221,** 1144, 1–28, Jan. 1954.

Relationships are developed for the simultaneous flow of gas and heat through a continuous porous solid. The velocity and both temperature distributions are developed as functions of space and time. Explicit solutions are obtained for a few special cases; however, numerical solutions are usually necessary.

W. L. Sibbitt, USA

1642. **Bayley, F. J., Air cooling methods for gas turbine combustion systems,** *Aero. Res. Counc. Lond. curr. Pap.* 113, 44 pp., Aug. 1951, published 1953.

Paper presents the results of calculations and experiments on convection cooling without and with extended surfaces, on transpiration cooling, and on film cooling with the application of cooling combustion cans in mind. Reviewer believes that because of severe simplifications necessary for the calculations and of limited range of the tests, care has to be exercised in using the presented relations outside the range in which they have been confirmed by measurements.

E. R. G. Eckert, USA

1643. **Bigg, E. K., The supercooling of water,** *Proc. phys. Soc. Lond.* (*B*) **66,** 404, 688–694, Aug. 1953.

It is shown that suspension of drops at the interface of two insoluble liquids represents a satisfactory method of studying the supercooling of water. The temperatures of supercooling thus found depend on the volume of the sample and the rate of cooling. The interrelation between temperature, volume, and time is derived theoretically from simple probability considerations and is shown to be consistent with experiment.

From author's summary by Y. S. Touloukian, USA

1644. **Chu, J. C., Lane, A. M., and Conklin, D., Evaporation of liquids into their superheated vapors,** *Indust. Engng. Chem.* **45,** 7, 1586–1591, July 1953.

Authors' equipment provides for generation and superheating of vapor, after which it passes through an evaporating chamber and then is condensed. Heat-transfer coefficients for 1-butanol, water, and benzene were determined experimentally for various vapor temperatures and evaporator feed rates. Authors conclude that thermal advantages of superheated vapor operation are very decidedly in favor of such operation. It appears that if a flammable liquid is to be evaporated, considerable advantage is gained due to absence of air in the system. The process is limited, of course, to relatively temperature-stable materials.

R. E. Gaskell, USA

1645. **Juhasz, I. S., and Hooper, F. C., Hydraulic analog for studying steady-state heat exchangers,** *Indust. Engng. Chem.* 45 6, 1359–1362, June 1953.

Paper reports on a method of using a hydraulic analog for solving some steady-state heat-exchanger problems. Method is novel in that it equates time in the model to heat-exchange surface in the actual equipment. By use of analog, problems of parallel and modified parallel flow, including variable specific heats and change of phase of the participating fluids, are solved.

W. A. Wolfe, Canada

1646. **Lauwerier, H. A., Diffusion from a source in a skew velocity field,** *Appl. sci. Res.* (*A*) **4,** 2, 153–156, 1953.

Author considers a two-dimensional fluid-flow problem in which the fluid flows with the nonuniform velocity $v = v_0(1 + ay)$ in the x-direction and the origin is a source of constant strength Q. Using the boundary condition $c = 0$ at $y = -1/a$, the diffusion equation $D\partial^2 c/\partial y^2 = v_0(1 + ay)\partial c/\partial x$ is solved by the Laplace transformation. The solution is shown to be a distribution function with slight skewness.

E. J. Scott, USA

1647. **Jamieson, J. R., Roose, R. W., Gilkey, H. T., and Konzo, S., Heat emission characteristics of warm-air perimeter heating ducts,** *Univ. Ill. Engng. Exp. Sta. Bull.* 412, 82 pp., 1953.

1648. **Weinberg, S., Heat transfer to low pressure sprays of water in a steam atmosphere,** *Instn. mech. Engrs. Proc.* (*B*) **1B,** 6, 240–253, 1952.

The mechanism of water flow and atomization in low-pressure swirl-chamber nozzles was investigated. Measurements of the rate of heat transfer from steam to water both in the film phase and in the drop phase were made. Measurements of the length and velocity of the film formed by the water as it emerges from the nozzle orifice were made and simple correlations developed. Droplet sizes were measured and correlated with the nozzle size and pressure drop. Temperature measurements in the film phase disclosed that 70 to 90% of the possible heat transfer from the steam to the water took place in the film phase. The percentage transferred to the film was a function of nozzle pressure drop and decreased rapidly as the pressure drop increased beyond one atmosphere. Heat-transfer rates appear to be higher for the film than for the droplets, but the data are not conclusive because of

uncertainty concerning the actual surface area in the film phase.

Reviewer believes that the author has somewhat overextended his data to reach general conclusions; a situation which is taken up at length in communications following the paper. His techniques seem quite good and the extension of them to higher pressure nozzles, etc., is desirable. C. L. Coldren, USA

1649. Waitkus, J., Methods for cleaning regenerative type air preheaters—Parts I, II, and III, *Combustion* **25,** 2, 3, 4; 40–45, 43–46, 49–53; Aug., Sept., Oct. 1953.

1650. Werner, F. D., and Keppel, R. E., An improved multiple shield gas temperature probe, Proc. Third Midwestern Conf. Fluid Mech., Univ. of Minn., 463–478, 1953.

The properties of a triple-shielded temperature probe, made of platinum and platinum alloys, for measuring total temperatures up to 1500 C are described. It is intended mainly for application in free flight at very high altitudes and velocities up to $M = 5.0$. Thermocouples are applied as sensing element. In normal cases error will not exceed a few per cent. Angles of attack up to 30° for $M < 1.5$ and up to 15° for $M = 4.5$ are without influence on results.

A heater of the storage type has been used for the tests and it may be of some interest to those concerned with preheating of air in special wind tunnels. S. F. Erdmann, Sweden

1651. Dauphinee, T. M., MacDonald, D. K. C., and Pearson, W. B., The use of thermocouples for measuring temperatures below 70° K. A new type of low temperature thermocouple, *J. sci. Instrum.* **30,** 11, 399–400, Nov. 1953.

The use of thermocouples such as copper-constantan to measure low temperatures (e.g., $\simeq$ 10 K) may result in considerable uncertainty in the measured temperature. These uncertainties are discussed and a method described for reducing them to ±0.5°. It is shown that thermocouples composed of pure copper against certain dilute copper alloys (e.g., copper + $\simeq$0.005 wt % tin) have particular advantages for measuring temperatures in the range 2–30 K. From authors' summary

Acoustics

(See also Revs. 1356, 1531)

1652. Powell, A., A survey of experiments on jet noise, *Aircr. Engng.* **26,** 299, 2–9, Jan. 1954.

Author presents a good summary and bibliography of British and American experiments on jet noise. An attempt is made to point out phases of the problem that have not been resolved. Some of the discrepancies between experiment and Lighthill's theory are also discussed. A. A. Regier, USA

1653. Lucas, R., Acoustical shocks caused by supersonic aircraft (in French), *C. R. Acad. Sci. Paris* **237,** 15, 780–782, Oct. 1953.

The aim of the paper is to determine the kinematic conditions for the simultaneous concentration at a point of observation of the acoustical disturbances caused by a source—like an aircraft—in the various points of its trajectory. Such concentrations would be—according to an earlier paper of Roy—the cause of acoustical shocks.

First of all, it is shown what trajectory must be followed by a source moving at constant speed in order to have concentration at a point P: it is a logarithmic spiral having the pole at P, of parameter related to the Mach number, which is real for supersonic flight only.

Secondly, author determines the relationship between speed and position for a source moving on a horizontal straight line, in order that the said concentration occur, and the positions for which the actual speed is coincident with the aforesaid theoretical one for uniformly accelerated flight. The positions are two and depend on the level of the source on the observation point and on its acceleration; they are the positions corresponding to the "sonic shocks" at P.

Finally, a short discussion is presented of the general case which can be treated by knowing the wave surface of spherical shocks caused by a source moving with nonuniform velocity.

P. Santini, Italy

1654. Guittard, J., Analysis of vibratory motions in a sounding pipe. Loop discontinuities (in French), *Acustica* **2,** 5, 231–236, 1952.

1655. Mikhaĭlov, G. D., Interaction of ultrasonic waves in liquids, *Dokladi Akad. Nauk SSSR (N.S.)* **89,** 4, 663–664, Apr. 1953; *Nat. Sci. Found.* tr-70, Sept. 1953.

Two traveling ultrasonic waves of frequencies ω_1 and ω_2 in the mc-range are superposed in turpentine and mixtures of turpentine with vaseline oil. The experiments show that the nonlinear properties of such viscous and compressible liquids lead to the generation of waves with frequencies $\omega_1 \pm \omega_2$. The use of this effect is suggested for measuring ultrasonic absorption.

F. E. Borgnis, USA

1656. Cady, W. G., and Gittings, C. E., On the measurement of power radiated from an acoustic source, *J. acoust. Soc. Amer.* **25,** 5, 892–896, Sept. 1953.

Paper reports experimental evidence in support of theoretical calculations by Borgnis [see following review] who deduced that the force acting on an absorber of a beam of plane acoustic waves in an attenuating beam was independent of the separation of source and absorber. A cavity resonator was used as the absorber and the force on it was measured by a torsion balance. Measurements were made of the force on an acoustically transparent membrane (force due to hydrodynamic flow) and also of the force on the cavity resonator when it was inserted behind the membrane (radiation pressure force). The sum of these forces at any common position remains constant when the separation of source and measuring point is varied. R. T. Beyer, USA

1657. Borgnis, F. E., On the forces due to acoustic wave motion in viscous medium and their use in the measurement of acoustic intensity, *J. acoust. Soc. Amer.* **25,** 3, 546–548, May 1953.

The nonlinear nature of the hydrodynamic equations results in a coupling between the acoustic field and a viscous steady flow. Author demonstrates that the acoustic streaming is not always a parasitic phenomenon but can be exploited for measuring purposes. Applying the momentum equation, one obtains the total force on an absorbing "target" irrespective of the numerical values of the viscosity and within limits—independent of the distance from the acoustic source. L. S. G. Kovasznay, USA

1658. Anderson, A. B. C., A circular-orifice number describing dependency of primary Pfeifenton frequency on differential pressure, gas density, and orifice geometry, *J. acoust. Soc. Amer.* **25,** 4, 626–631, July 1953.

As the rate of flow of gas through a pipe-orifice assembly is varied, thereby increasing or decreasing the differential pressure across the orifice, discrete ranges of self-excited frequencies are

produced; the primary Pfeifentöne are defined as the frequencies at the low-pressure, low-frequency ends of the discrete ranges. These frequencies, although here self-excited, are the natural longitudinal frequencies of the air column inside the pipe-orifice assembly in the absence of the flowing gas. The general form of the relations determining these frequencies is considered by means of dimensional analysis. The dimensionless quantity $[(\Delta p/\rho)^{1/2}/ft]$ is proposed as characteristic; here Δp is the differential pressure across the orifice, ρ the density of the gas, f the frequency, and t the thickness of the orifice plate terminating the pipe. Experimental data are presented to show that this quantity is relatively constant for certain ranges of the orifice diameter, pipe length, frequency, and differential pressure.

V. Twersky, USA

1659. **Kuhl, W., and Tamm, K., Sound propagation in cylindrical columns of liquids with soft walls** (in German), *Acustica* **3**, 2, 303–316, 1953.

This work, heretofore available in a Navy report of limited distribution, was done in the period 1940–1943. It is a comprehensive analytical and experimental investigation of the effect on sound propagation in a tube, the walls of which are lined with a pressure release material such as cellular rubber. It turns out that a plane wave can be propagated down the tube only if the wall is rigid or presents a stiffness reactance. For the first two transverse modes the wall impedance may be chosen to maximize their damping; however, the attenuation of higher modes will then be smaller.

V. Salmon, USA

1660. **Gösele, K., Sound radiation by plates undergoing flexural vibration** (in German), *Acustica* **3**, 4, 243–248, 1953.

Plates of infinite extent undergoing flexural vibration do not radiate sound energy if the wave length of their vibration is smaller than the wave length in the adjoining fluid medium. Author has analyzed finite plates to determine to what extent they display this cut-off phenomenon. He finds that this phenomenon is increasingly less pronounced as the size of the plate is reduced; however, even when the plate is only three wave lengths long, there is a drop of approximately 12 db's at cut-off. Well above cut-off, radiation is rather independent of frequency and of source area; it rises to a maximum just before reaching cut-off. Well below cut-off, radiation is again independent of frequency; since the cut-off feature is more pronounced for larger plates, an increase in plate area does not increase the amount of energy radiated.

This analysis has obvious applications to the practical problem of sound insulation.

M. C. Junger, USA

1661. **Cremer, L., Theory of attenuation for sound propagation in a rectangular tube containing an absorbing wall** (in German), *Acustica* **3**, 2, 249–263, 1953.

The attenuation constant is calculated for sound propagation in a rectangular tube containing one absorbing wall of impedance W. Taking into account the variation of sound pressure perpendicular to the axis of the tube leads to the diagram of Morse, which, however, furnishes only preliminary quantities from which the attenuation constant must be calculated for a given frequency. From this diagram five charts are derived from which (for five different frequencies) the attenuation constant can be read directly. These charts show that the highest attenuation is obtained when the wall impedance is

$$W = (0.91 - 0.76i)(2h\rho c/\lambda)$$

where ρc is characteristic impedance in air, λ wave length, h width of tube perpendicular to the absorbing surface. With this wall impedance, the decrease of level per unit width of the tube is 19 db for low and $3.5\lambda/h$ db for high frequencies.

From author's summary by F. R. N. Nabarro, South Africa

1662. **Gerber, O., Experimental investigation of the high attenuation theoretically possible for propagation of sound in a rectangular tube** (in German), *Acustica* **3**, 2, 264–270, 1953.

An apparatus is described for measuring the attenuation constant of a narrow, rectangular tube, one wall of which is absorbent. The absorbing wall consisted of homogeneous layers of sound-absorbing material of small flow resistance interrupted by partition walls. With suitably chosen flow resistance and a tube width of 5 cm, attenuation constants of 170 to 200 db/m could be obtained for certain frequencies. Furthermore, wall impedances are described which produce a mean value of attenuation of 60 db/m in a wide frequency range. The observations agree with the theory of Morse and of Cremer (see preceding review).

From author's summary by F. R. N. Nabarro, South Africa

1663. **Oura, H., Sound wave in snow cover,** *Jap. Sci. Rev* **2**, 4, 373–374, Sept. 1952.

Ballistics, Detonics (Explosions)

1664. **Cope, W. F., A comparison of calculated and measured base pressures of cylindrically based projectiles,** *Aero. Res. Counc. Lond. curr. Pap.* 118, 12 pp., May 1952, published 1953.

Basis for author's theory is that immediately behind the base there is a frustum of still air following projectile. Height of frustum (in caliber) is obtained by measurement of photographs of projectiles in flight and in wind tunnels. From this, from equations of continuity and of energy, and from an assumed velocity distribution in boundary layer, author determines base pressure as function of length of projectile (in caliber), Mach and Reynolds numbers. Agreement with measured values is satisfactory. Drop of base pressure with increasing Reynolds number is remarkable. Effect of surface roughness on results is not discussed.

Å. Silfverhielm, Sweden

Soil Mechanics, Seepage

(See also Revs. 1495, 1673)

1665. **Rocha, M., Similarity conditions in model studies of soil mechanics problems,** *Minist. Obras Públ., Lab. Engen. civ. Lisboa Pub.* no. 35, 15 pp., 1953.

After emphasizing the limitations of the analytical methods in soil mechanics, similarity conditions are presented which should be fulfilled by models to be used in studying the problems posed by soil masses to the engineer.

The general conditions are first presented which should be met by prototypes, consisting of saturated or unsaturated soils and acted upon by surface forces and dead weight. Then some particular cases of practical significance are considered, such as that of equilibriums in which the percolation of pore water is neglected, that in which the final state of the mass, more especially the failure, is assumed not to depend on the intermediate states, etc. Cases are pointed out in which the materials of the prototype can be used for the construction of the models.

Some general indications are advanced on the path to be followed in finding materials that fulfill the requirements for similarity. Emphasis is laid on the fact that, as a rule, it does not

make any sense to be too exigent with regard to the fulfillment of those requirements.

Finally, attention is drawn to how valuable an aid models can be in studying the problems posed by soil masses.

From author's summary by R. K. Bernhard, USA

1666. Cherniak, G. Ya., Determining the natural porosity of water-saturated sands by the method of electric capacity (in Russian), *Gidrotekh. Stroit.* no. 3, 32–34, Mar. 1953.

Paper describes an electrical method of determination of void ratio of saturated sand in its natural undisturbed state. A special condenser with pointed conical end is placed on the end of the drill rod and is driven below the bottom of the drill hole. Its electrical capacity depends on the void ratio of the surrounding saturated sand and is observed by means of a special electronic meter, which also makes allowance for the presence of soluble salts in water. A linear calibrating graph for this condenser, giving the relation between its capacity and the dielectric constant, allows finding the value of the latter for the sand. A disturbed sample of this sand is then taken from the drill hole, is dried and placed into another condenser in the form of a cylindrical cup, partly filled with water. The sand is compacted to different values of void ratio, and for each value the capacity of the condenser is observed and translated into the dielectric constant, thus allowing construction of a graph of the void ratio on the basis of the dielectric constant, from which the void ratio of the undisturbed sand can be easily read, using the true value of the dielectric constant. Close agreement is claimed for this method in comparison with the direct determination of the void ratio from the undisturbed samples. The method at present is undergoing tests on several hydroelectric construction jobs.

Reviewer feels that driving of the condenser is likely to disturb the natural state in soil and to change its void ratio.

A. Hrennikoff, Canada

1667. Bishop, A. W., and Henkel, D. J., A constant-pressure control for the triaxial-compression test, *Géotechnique, Lond.* **3,** 8, 339–344, Dec. 1953.

In many tests on soils, carried out in the triaxial comparison apparatus, it is essential to maintain a constant ambient pressure in the cell for periods of several hours and often for several days. Yet some leakage of the ambient fluid (usually water) is inevitable through the piston gland. The authors describe a most ingenious and simple device whereby a constant pressure can be maintained independent of any reasonable amount of leakage. This consists of a self-compensating mercury manometer which, in the form used, can apply pressures of up to about 150 psi. Its practicability has been proved over a period of three years and the maintenance work required has been negligible. The principle might well be employed in other cases where a constant pressure has to be maintained for long periods. It avoids any mechanical or electrical control apparatus. A. W. Skempton, England

1668. Schmertmann, J. H., Estimating the true consolidation behavior of clay from laboratory test results, *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 311, 26 pp., Oct. 1953.

"Undisturbed" samples of cohesive soils are subjected to varying degrees of disturbance depending on methods and care used in obtaining them. This disturbance causes the laboratory pressure-void ratio curve obtained from consolidation test to be displaced with respect to the true field curve. Paper presents a method of quantitatively correcting the laboratory consolidation curve to the field curve. A new approach to estimating preconsolidation pressure is also given. Numerical example of settlement analysis using proposed method shows excellent agreement between computed and observed settlements for structure on a clay foundation. Method is also shown for correcting laboratory time-consolidation curves for effects of sample disturbance.

W. G. Shockley, USA

1669. Meyerhof, G. G., and Murdock, L. J., An investigation of the bearing capacity of some bored and driven piles in London clay, *Géotechnique, Lond.* **3,** 7, 267–282, Sept. 1953.

The article describes a soil investigation and loading tests which were made on bored and driven concrete piles in London clay to study their bearing capacity and settlement. It was found that the shearing strength of the fissured clay decreased rapidly with time after sampling, due to opening of the fissures which could not be closed sufficiently by large triaxial pressures.

Water from concrete of bored piles installed in an unlined auger bore hole softens the clay and this softening could not be avoided except by an unworkable dry mix. While the point resistance can be based on the natural shearing strength, the skin friction of these bored piles is closely given by the fully softened strength. On the other hand, the skin friction of concrete piles driven into still too hard clay seems to have an upper limit of 2000 lb/ft². At a factor of safety of 3 against shearing failure, the settlement of widely spaced bored and driven piles in London clay is unlikely to be greater than one inch. From authors' summary

1670. Rocha, M., and Folque, J., Some results of settlements observations in actual structures and in models, *Minist. Obras Públ., Lab. Engen. civ. Lisboa Pub.* no. 36, 6 pp., 1953.

Models of 1/100 scale of two stratified foundations, made with undisturbed soil samples, produced settlements closer to the prototype than calculations from consolidation tests. Settlements predicted from bearing tests on 0.3 and 1.5 meter square plates on sand agreed with observed settlements of ring footings.

E. S. Barber, USA

1671. Minnick, L. J., and Meyers, W. F., Properties of lime-flyash-soil compositions employed in road construction, *Nat. Res. Counc. Highway Res. Bd. Bull.* 69, 1–28, 1953.

Study of various soils to which lime fly ash was added showed increase in compressive strengths to approximately 1000 psi at 28 days under standard curing and high weathering resistance even after 12 freeze-thaw cycles. Paper gives excellent description of a rugged, stable, and inexpensive pulse-velocity meter, and shows that pulse-velocity readings can be correlated to compressive strength and weathering resistance. Description of apparatus is sufficiently detailed to allow reader to build his own.

From authors' summary by R. Quintal, Canada

1672. Schultze, E., Soil mechanics problems in mining (in German), *Bautech.-Arch.* **8,** 30, 71–78, 1952.

Micromeritics

(See also Rev. 1523)

1673. Collis-George, N., Calculation of the permeability of porous media from their moisture characteristics, *Trans. Amer. geophys. Un.* **34,** 4, 589–593, Aug. 1953.

An interpretation of the moisture characteristic, or the relationship of moisture content to hydrostatic pressure deficiency of a porous medium is outlined, giving the pore-size distributions involved in the simultaneous flow of a wetting and a nonwetting fluid. A method is described by calculating intrinsic permeabilities to air and water flow at all fluid contents.

From author's summary

Geophysics, Meteorology, Oceanography

(See also Rev. 1686)

1674. **Northwood, T. D., and Anderson, D. V., Model seismology,** *Bull. seism. Soc. Amer.* **43,** 3, 239–245, July 1953.

Paper considers the problem of setting up a model for the investigation of the propagation of pulses along the free surface of a solid. This is the classical problem discussed by Lamb [*Phil. Trans.* (*A*) **203,** 1–42, 1904]. The experimental setup was a uniform block of specially finely mixed concrete, $3 \times 2 \times 1$ m. The pulse generator and receiver were small Rochelle salt transducers giving pulses of 30–50 microsec with a repetition frequency of 100 cycles. Some experimental results are reproduced and compared with Lamb's results. Though care was taken to make the concrete as homogeneous as possible, the trace of the P part of the wave was obscured in some cases by reflection from inhomogeneities in the medium. The main phases P, S, and Rayleigh waves are well shown; the effect of a source generating only S waves was also investigated. The method would appear to have considerable value as a demonstration model, but further work is required to make it a closer approximation either to theoretical models or to field conditions. J. M. Jackson, Scotland

1675. **Kanai, K., Osada, K., and Yoshizawa, S., The relation between the amplitude and the period of earthquake motion,** *Bull. Earthq. Res. Inst., Tokyo Univ.* **31,** 1, 45–55, Mar. 1953.

1676. **Bolin, B., Multiple-parameter models of the atmosphere for numerical forecasting purposes,** *Tellus* **5,** 2, 207–218, May 1953.

Author discusses critically recent developments in numerical forecasting, presuming familiarity with the material. He emphasizes that by judicious choice of assumptions concerning the vertical variation of the thermal pattern ("two-parametric" model), a wider range of baroclinic situations can be represented than heretofore, without materially adding to the computations. Incorporation of further detail is also unjustified as exceeding the accuracy of observations. An interesting but inconclusive example is given of a forecast computed by a graphical technique [see Fjortoft, AMR **6,** Rev. 1771]. M. Wurtele, USA

1677. **Imahori, K., and Kobayashi, T., On the long-period forecasting by means of harmonic analysis,** *J. meteor. Soc. Japan* **29,** 11, 365–378, 1951.

1678. **Ludlam, F. H., and Scorer, R. S., Convection in the atmosphere,** *Quart. J. roy. meteor. Soc.* **79,** 341, 317–341, July 1953.

This is the tenth in a series of review articles on modern meteorology. It summarizes present state of knowledge of the process of convection with particular reference to the structure and growth of cumulus-type clouds. Due to the lack of sufficiently detailed observations on the initiation and maintenance of convection processes, the theory of convection is essentially a qualitative one. The current most widely accepted model is one in which a succession of air bubbles rise, intersect, and decay from an area whose geometrical properties or soil parameters combine to give an area which is somewhat warmer than its surroundings. The extent to which this rising thermal will grow into a fully developed cumulus cloud depends on such parameters as atmospheric stability, vertical wind shear, available moisture, and the larger scale synoptic features of the atmospheric circulation. Although laboratory studies of heated jets and stationary cellular patterns have been partially successful in studying certain of the properties of thermals, aircraft in general and gliders in particular are the best available measuring instruments. Author concludes that although physical structure of cumulus and cumulo-nimbus clouds is fairly well known, new theories of convection are needed to account for these properties. Reviewer believes that the article is a comprehensive, significant, and well-written summary of available knowledge in this field and should be of interest to both the theoretical meteorologist and the practicing forecaster. J. R. Gerhardt, USA

1679. **Syōno, S., On the formation of tropical cyclones,** *Tellus* **5,** 2, 179–195, May 1953.

The investigation is based on the following model: From the vertical mass transport in numerous convection cells a mean horizontal pressure gradient is created, outflow aloft and inflow below. If convection continues, cyclonic motion will be generated through the action of Coriolis forces. The stability of such a model is investigated with the help of perturbation equations under the assumption of initially constant vertical instability. The latent heat of moist air is taken into account using a polytropic method, where the equation of adiabatic change $pv^\gamma = \text{const}$ is replaced by $pv^k = \text{const}$, $\gamma > k > 1$. In the case of a barotropic atmosphere, the stability criterion becomes: $-gS/Z^2 \gtrless 76n^2r_0^2$ where S, Z, n, and r_0 are the vertical (thermal) stability, relative vorticity, number of loops of the perturbation in vertical direction, and horizontal dimension in 100 km. The vertical shear has small effects upon typhogenesis, but too strong positive shear acts as stabilizing. Different modes of perturbation are investigated. It seems possible to apply solution to the case of an actual typhoon by means of generalized Fourier synthesis. Basic ideas of this paper have been applied by Kasahara in a recent report [AMR **7,** Rev. 979]. H. Merbt, Sweden

1680. **Arakawa, H., Critical study on the angular-momentum-transfer method and vorticity-transfer method in the investigation of zonal circulation of the atmosphere,** *J. meteor. Soc. Japan* **31,** 4, 16–22, Apr. 1953.

Author inquires into the effects of meridional displacements under two different sets of assumptions: First, that the east-west pressure gradient is zero everywhere and the total angular momentum is conserved; and second, that the fluid is incompressible and the vertical component of the absolute vorticity is conserved. He finds large displacements lead to very high zonal velocities under the first set of assumptions and to reasonable values under the second. A. Fleischer, USA

1681. **Queney, P., Internal resonance in the jet-stream and its role in the formation of depressions,** *Proc. Indian Acad. Sci.* (*A*) **37,** 2, 213–222, Feb. 1953.

Paper discusses the behavior of perturbations of a barotropic current of uniform direction in which the velocity varies across the current. The velocity profile of the current is idealized by treating it as two currents, each with uniform velocity gradient separated by a line of discontinuity in wind shear—a discontinuity of vorticity. The possible sinusoidal perturbations are discussed, including those which involve supplementary lines of wind shear. Certain perturbations are possible which give rise to infinite displacements of some fluid elements and are regarded as unstable.

The author identifies his current with the jet stream and its unstable disturbances with cyclones. However, it is difficult to decide how far the nature of his results depends on the artificialities of his model, and the relation of his mathematics to the atmosphere is far from certain. J. S. Sawyer, England

Lubrication; Bearings; Wear

(See also Rev. 1490)

1682. Raimondi, A. A., and Boyd, J., Applying bearing theory to the analysis and design of pad-type bearings, Parts I and II, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-84, 35 pp.

Charts are presented which enable easy calculation of effect of design parameters on operating variables for both fixed and pivoted pad bearings. Coefficient of friction, power loss, minimum film thickness, oil flow, and film temperature rise can be calculated. Charts were prepared from work in *J. appl. Phys.* [11, p. 208, 1940] for the case of constant viscosity. Reviewer believes latter assumption is not even approximately true since it results in zero load capacity for centrally pivoted sliders which are in widespread use and which work. Designers must therefore be cautious in using these charts, for calculated conditions may deviate considerably from actual conditions in some applications. W. J. Anderson, USA

1683. Uhlig, H. H., Feng, I. M., Tierney, W. D., and McClellan, A., A fundamental investigation of fretting corrosion, *NACA TN* 3029, 52 pp., Dec. 1953.

Apparatus built at MIT under sponsorship of NACA is described and results are presented for mild steel rubbing against mild steel under different conditions of humidity, temperature, time, atmosphere, relative slip, pressure, and oscillation frequency. Damage is determined by weight loss. Damage is found to be associated with α Fe_2O_3 formation, and a mechanism for fretting damage is presented. M. C. Shaw, USA

1684. Hagg, A. C., and Warner, P. C., Oil whip of flexible rotors, *Trans. ASME* **75,** 7, 1339–1344, Oct. 1953.

Bearing oil-whip studies are extended to include effect of flexible rotors. It is shown that rotor flexibility reduces the region of stable operation. E. F. Macks, USA

Marine Engineering Problems

(See also Rev. 1631)

1685. Bocler, H., The position of longitudinal centre of buoyancy for minimum resistance, *Trans. Instn. Engrs. Shipb. Scot.* **97,** part I, 11–48, 1953–1954.

Paper reviews available data relating to optimum position of longitudinal center of buoyancy (L.C.B.) for minimum resistance of single- and twin-screw ship forms. It records an investigation sponsored by the British Shipbuilding Research Association. Diagrams are given showing L.C.B. as functions of block coefficient and corresponding speed-length ratio defined by the old Alexander formula. The mean curves as presented should be used with some caution since the experiments referred to were largely conducted without turbulence stimulation. In comparison with data for stimulated models available to reviewer, the author's recommended L.C.B. are rather far forward for single-screw and aft for twin-screw ship forms. However, the L.C.B. is by no means very critical and the curves show correct tendencies. The summary of data as presented is useful to the naval architect. L. Troost, USA

1686. St. Denis, M., and Pierson, W. J., Jr., On the motions of ships in confused seas, Soc. nav. Arch. mar. Engrs., Prepr. Ann. Meeting, Nov. 1953. Pap. no. 2, 53 pp.

Authors apply statistical mathematics to the problem of defining the confused, complex sea found in nature and of determining the resultant motions of ships operating in that sea. Such an irregular sea, in authors' opinion, can be adequately represented by a Lebesgue energy integral for the Gaussian case. Functions, called response-amplitude operators, are derived. These operators are defined as the amplitude of the ship's motion (heave, pitch, or roll) which occurs in response to a regular sea of unit amplitude. The product of the energy spectrum of a regular seaway and the response-amplitude operator is transformed to a coordinate system moving with the vessel. The response of the vessel in a confused sea is then derived, assuming that the sum of the responses of the ship to a number of simple sine waves is equal to the response of the ship to the sum of those waves.

From the principles developed, the following practical applications are apparent: (1) It should become possible to predict the amplitude of pitch, heave, and roll of ships operating in confused seas, provided the results of model tests at various headings in regular waves are available. (2) The probability of a ship encountering waves of particular amplitude may be predicted, using the Gaussian probability law. P. Mandel, USA

1687. Tomalin, P. G., Marine engineering as applied to small vessels, Soc. nav. Arch. mar. Engrs., Prepr. Ann. Meeting, Nov. 1953. Pap. no. 8, 24 pp.

Design criteria are stated for vessels of lengths in the order of 125 ft. Charts and nomograms are given for rapid estimates of relevant design parameters. Recommendations are made as to selection of machinery and to reduction of propeller-excited hull vibrations. H. W. Lerbs, USA

1688. Dawson, J., Resistance of single-screw coasters. Part I. L/B = 6, *Trans. Instn. Engrs. Shipb. Scot.* **96,** part 6, 313–372, 1952–1953.

Earlier experiments at N.P.L. with coaster models, results of which were published in six papers by F. H. Todd and J. Weedon between 1931 and 1941, gave valuable data and resulted in introduction of cruiser stern in all coasters. The cruiser stern demanded a smaller diameter propeller the revolutions of which were increased. The faster running diesel engines had less weight, less machinery space was required, and it became possible to have finer lines in the afterbody, thus giving lower resistance and better flow to the screw. Propulsive efficiency was increased further by fitting a fin on the fore side of the stern post.

The changes in design and in technique of model testing since 1948 have resulted in a new research program for coasters at N.P.L. The present paper reports on the results of resistance tests of models with L/B = 6 as part of this program. Block coefficients used were 0.75, 0.70, and 0.65. Longitudinal position of center of buoyancy was varied. A limited investigation of the influence of variation in midship-area coefficient was also made. Paper gives body plans, water lines, and area curves of models, and test results in graphs and tables.

The use of trip wire to obtain turbulent flow shows an increase in resistance of about 10% at service speed, with fuller forms compared with results with no trip wire. G. Vedeler, Norway

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